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VOL. X FEBRUARY, 1923 No. 2

STUDIES OF THE MECHANISM OF MOVEMENT OF THE MUCOUS MEMBRANE OF THE DIGESTIVE TRACT*

BY GÖSTA FORSSELL, M.D.

STOCKHOLM, SWEDEN

THE folds of the mucous membrane of the stomach are generally supposed to be caused by a passive folding-in, as a consequence of the contraction of the muscular coat (muscularis propria). The origin of some of the folds of the mucous membrane of the intestines is explained in this manner; other folds are supposed to be permanent anatomical structures.

I have proved that this prevailing opinion is not correct, the folds of the mucous membrane of the alimentary canal being formed by active movements of the mucous membrane itself.

By pictures of anatomical preparations, series of roentgenograms and photographs of the digestive tract of living beings, I shall attempt to show how I arrived at this opinion, which differs from the prevailing view.

Figure 1 shows the surface of the mucous membrane of a normal stomach. The stomach is cut in the curvatura major and opened, showing a surface of the same width on both sides of the curvatura minor. The mucous membrane of the posterior and anterior walls of the stomach shows, notwithstanding, a relief of a totally different type.

To the left of the curvatura minor there are high folds with close transverse folds, while to the right there are only a small number of low folds. The surface of the mucous membrane between these low folds shows a fine mammillated surface, the so-called *état mamelonné*. By comparing the areas of the anterior surface with the corresponding areas of the posterior surface, the difference will be found striking.

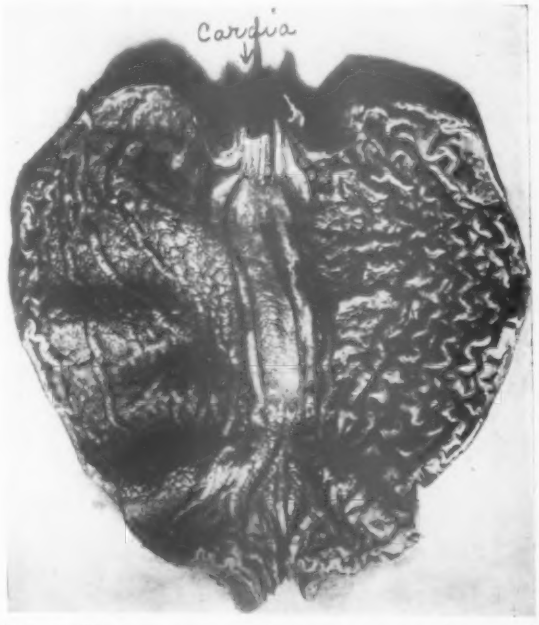

FIG. 1. The mucous membrane of a normal stomach.

In Figure 2, you will be able to ascertain how the relief of the mucous membrane in one and the same stomach is not only essentially unlike in the areas with about

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

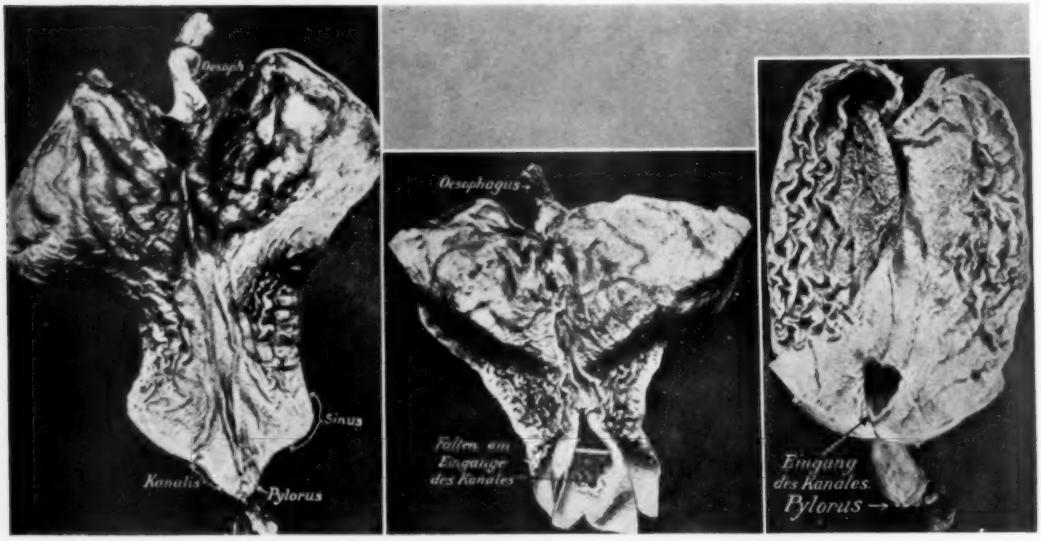

FIG. 2. Photos of the mucous membranes of three human stomachs reproduced in the author's work, Über die Beziehung der Rontgenbilder des menschlichen Magens zu seinem anatomischen Bau Hamburg, 1913.

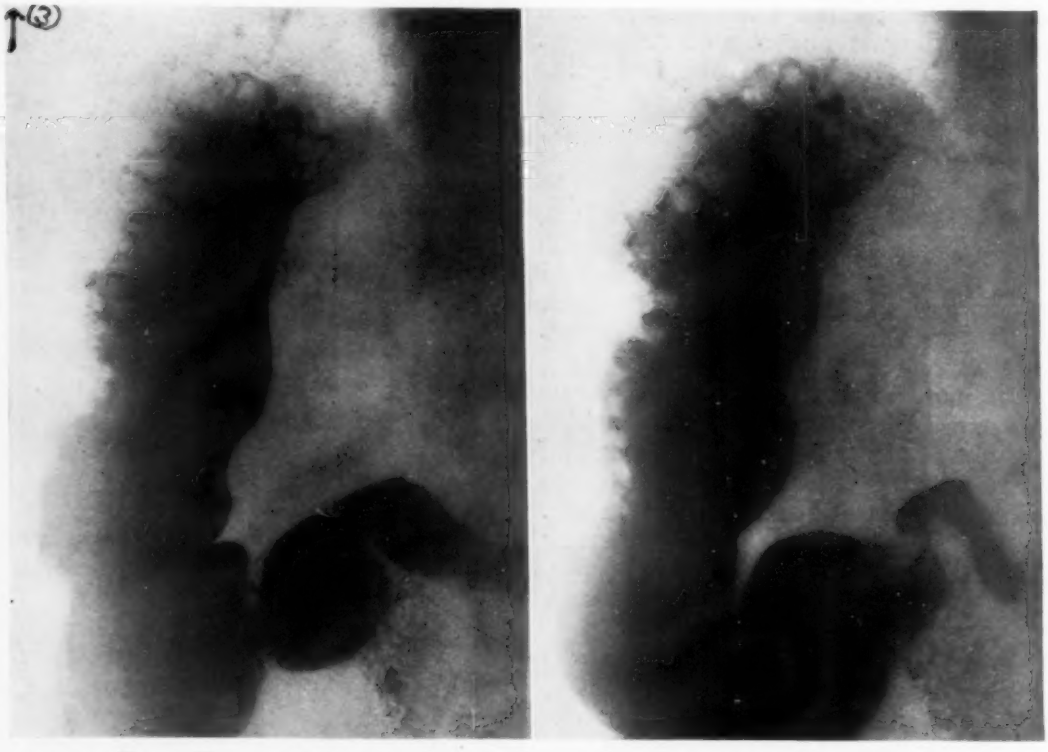

FIG. 3. Two roentgenograms of a normal stomach made at a one-minute interval.

the same width of muscular coat, but that different stomachs show very different reliefs of the mucous membrane in corresponding areas with about the same contraction of the muscular coat.

is then contracted through the building of a kind of mammillated surface. Thus arises the so-called *état mamelonné* (mammillated state) which is a form of contraction of the mucous membrane.

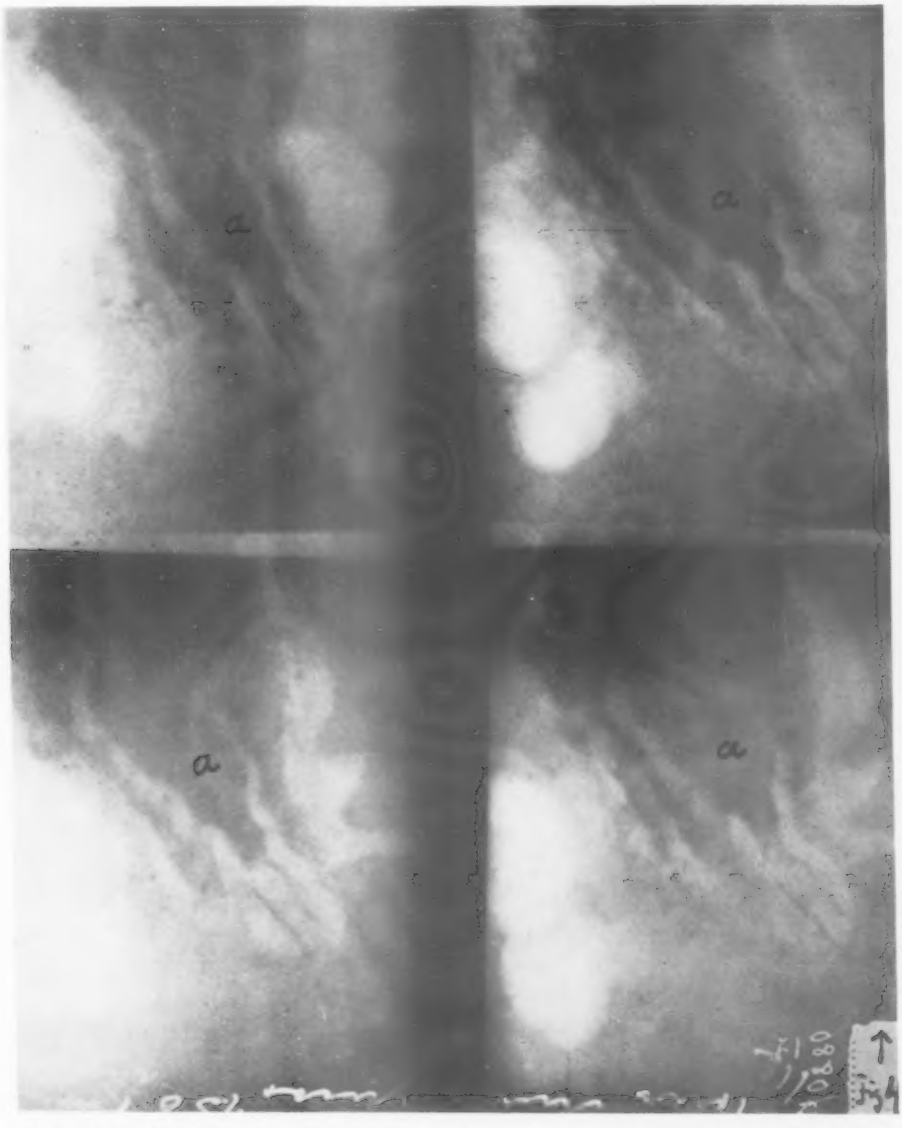

FIG. 4. A series of four roentgenograms of a limited area of the corpus ventriculi showing the mucous membrane, made at one-half minute intervals.

In all these stomachs, shown in Figure 2, it can be observed that the mucous membrane, even in very strongly contracted areas (for instance, in the area of the sinus in Figure 1) can maintain a foldless surface. The mucous membrane

Many pictures of the same kind caused me to doubt the correctness of the old explanation of the origin of the folds of the mucous membrane. It seemed to me unlikely that a purely passive folding-in of the mucous membrane could produce

so different a folding of the mucous membrane with an apparently similar contraction of the underlying muscular coat. The thought arose then, that possibly the relief of the mucous membrane was formed independently of the contraction of the muscular coat through independent and appropriate movements of the mucous membrane itself; that therefore, the relief of the mucous membrane, as it was shown on the anatomical preparations, and in the roentgenograms, represented a phase of a state of movement.

Hence, my attention was directed towards the attempt to observe movements of the contours of the mucous membrane; and, in 1912, I succeeded with the help of radioscopy to observe movements of the mucous membrane in the upper part of the stomach. Later on I succeeded, with the help of improved technique, in demonstrating in a series of roentgenograms a visible movement of the folds of the mucous membrane.

Figure 3 shows two roentgenograms of a normal stomach, at an interval of one minute, in an unchanged prone position. If one compares the contours of curvatura major in its upper half, where the mucous membrane shows deep folds, one will observe how the folds of the mucous membrane changed their number as well as their position and form, without the stomach at this point having visibly changed its width.

Figure 4 shows a series of four roentgenograms of a stomach made in the supine position, at intervals of half a minute. A careful study will show that the folds of the mucous membrane have changed form and width in this short time. Attention should be directed to the changing forms and width of the groove between the two folds marked with *a*.

Figure 5 shows the change of the folds of the mucous membrane within the pyloric canal (area *a*) on two roentgenograms made in the standing position at an interval of about three-quarters of a minute. The width of the pyloric canal is about the same and the circular contraction of the muscular coat is situated in about the same area on the edge of the pyloric canal. But the number, form and position of the folds of the mucous membrane are apparently different in both roentgenograms. (*P*, pylorus.)

In a state of greater expansion of the muscular coat no folds appear on the

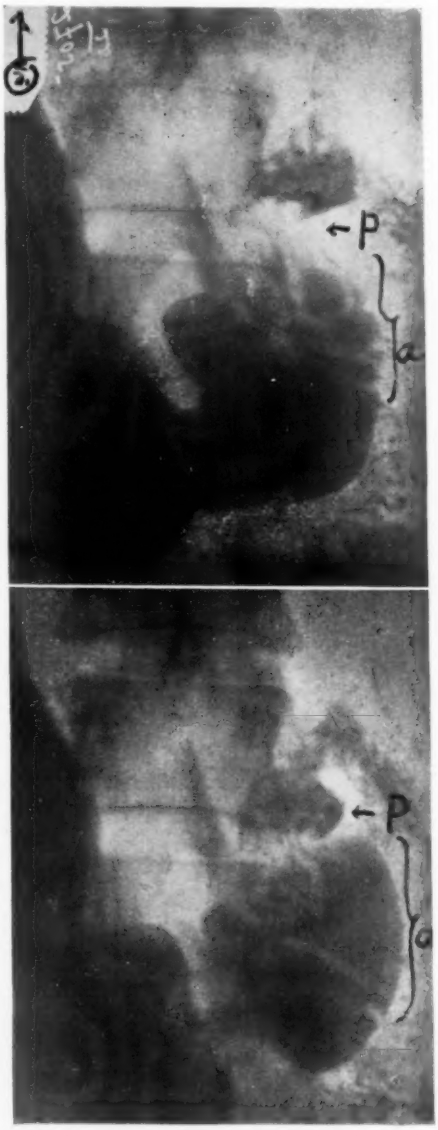

FIG. 5. Two roentgenograms showing the mucous folds of a pyloric canal, made at an interval of about forty-five seconds.

mucous membrane. A certain degree of contraction of the muscular coat with corresponding diminution of the cavity of the stomach seems, therefore, to be necessary for a formation of the folds on the surface of the mucous membrane.

However, folds on the mucous membrane appear synchronously with a moderate contraction of the muscular coat of the stomach. Especially during the later period of digestion, and, above all, when in a recumbent position, the lower part of the stomach contracts to form a channel, a rich relief of the mucous membrane appearing.

Figure 6 shows a series of cross-cut pictures of the lumen of the stomach, drawn after anatomical preparations. It can be seen how the lumen of the stomach with the same width of the muscular coat, can vary considerably through different foldings of the mucous membrane, with regard to the form, as well as to the width, of the inner surface of the stomach.

Through such forms of contraction of the mucous membrane, which are shown in Figure 6—and many other combinations are further possible—the lumen of the stomach may be formed either as a channel with smooth sides or be divided into different canals or systems of fissures between the lamellæ. These may be placed in different ways, so that a filtering or sorting of the contents can take place; or the small parts of the contents may be covered with a mucous membrane in small digestion chambers, in order to be emptied into the cavity in an appropriate state of digestion.

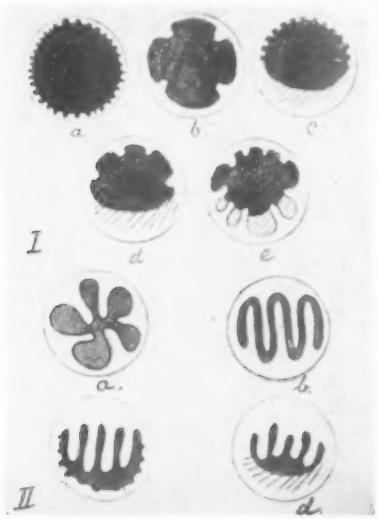

FIG. 6. A series of cross-cuts of the lumen of the stomach drawn after anatomical preparations.

Similar to what has just been stated in regard to the folds of the mucous membrane of the stomach, obtains in regard to the folds of the mucous membrane of the intestines. From the earliest times, the point of view has prevailed that the folds of the mucous membrane are passive structures, and the supposition was that they either originated through a folding-in of the mucous membrane by the contraction of the muscular coat, or that they were permanent anatomical structures (*Dauerfalten*). Even the roentgenological literature is dominated by the same theory. A finer division of the contents of the intestines, or an increased width of the folds, is supposed to depend on hypertrophy.

The bulbus duodeni is described as free from folds of the mucous membrane, and different anatomical forms are attributed to the valvulae conniventes of the

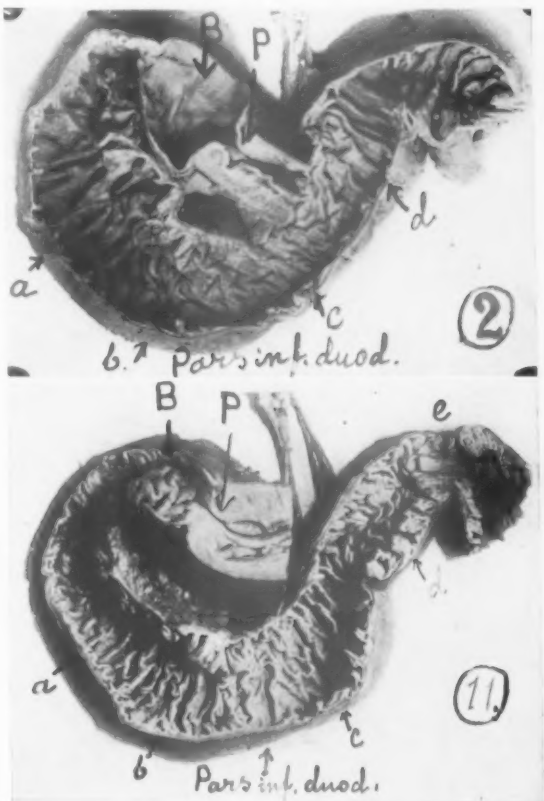

FIG. 7. Two normal anatomical preparations of the mucous membrane of the duodenum. P = pylorus. B = duodenal bulb.

duodenum and the small intestines. All thought of a change of form of the folds of the mucous membrane, on account of a movement of their own, has been completely ignored. But a closer study of the structure of the relief of the folds of the mucous membrane of the intestines on anatomical preparations and on the living intestines will give rise to another view.

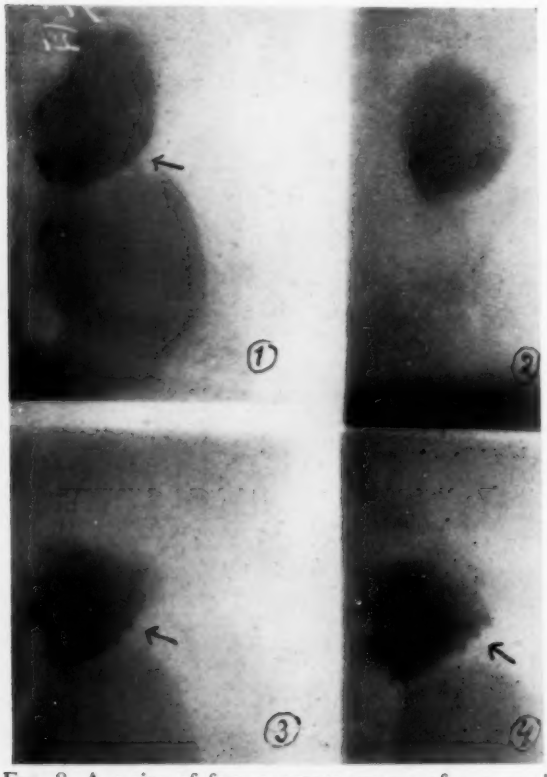

FIG. 8. A series of four roentgenograms of a normal duodenal bulb.

Figure 7 shows two anatomical preparations (2, 11) of the duodenum from patients with normal intestinal canals, who died of pneumonia. The preparations represent the posterior half of the entire duodenum. The stomach is cut away through the canalis pylori. (*P*, pylorus; *B*, bulbus duodeni.)

The upper preparation on the picture shows a bulb with smooth mucous membrane, as it is generally described. In the lower picture the mucous membrane in the bulbus is deeply folded with cerebral gyrus-like folds. If comparisons are made between the different areas of the same duodenum, for instance, between the areas *a* and *d* of the lower preparation, it will be noted that in spite of the duodenum having the same outer width, area *a* has low, simple folds, few in number, and a wide lumen, whereas area *d* has high, complicated, closely-placed folds and a narrow lumen.

These phenomena are not unique, but appear everywhere in well-conserved, anatomical preparations of the duodenum. The bulbus duodeni, which until now was supposed to be free from folds, has a very

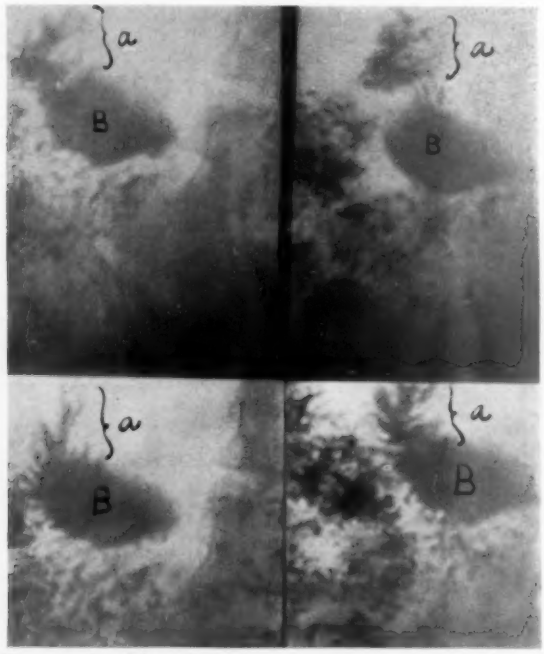

FIG. 9. A series of four roentgenograms of a normal duodenal bulb and the superior part of the duodenum, made at two-minute intervals.

changeable relief of the mucous membrane, similar to the entire duodenum.

The depth and form of the relief of the mucous membrane are not directly dependent on the width of the intestines (degree of contraction) since the most dissimilar reliefs of the mucous membrane may occur at a certain width of the intestinal canal.

An important question presents itself now: Are these folds characteristic of individuals and eventually for locality, or do they change here, as in the stomach, in the same place?

The following illustrations will solve this

question: Figure 8 shows a series of four roentgenograms of a bulbus duodeni, which, in the first, shows a quite smooth surface of the mucous membrane. In No. 3, small, typical folds of the mucous membrane appear on the basal surface of the bulbus (*a*), and in No. 4, these small folds have changed position, number and depth. A folding of the basal surface of the bulbus has taken place and the fold has shown an apparent movement.

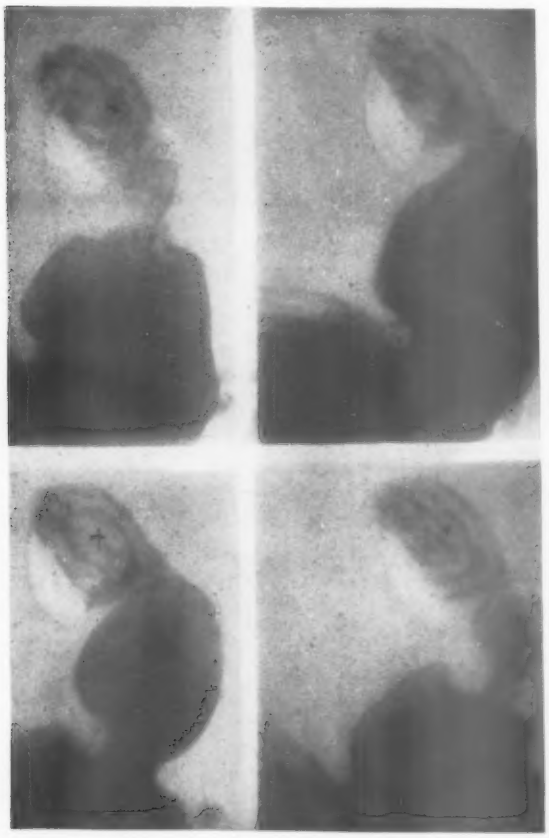

FIG. 10. Four roentgenograms showing a normal duodenal bulb.

Figure 9 shows a series of four roentgenograms, made at intervals of two minutes, of a bulbus duodeni (*B*) and a pars superior duodeni (*a*); and it will be observed how, in all of them, the contours of the mucous membrane have apparently changed, altering position, form, direction and height of the folds. Figure 10 is a new series of four roentgenograms in which the folds of the mucous membrane in the bulbus appear distinctly, on account of the bulbus being partly filled with air, partly with a contrast meal.

By comparing the areas marked with a cross, it is easy to observe the movement of the folds of the mucous membrane, which changed the position and form during the intervals between the different exposures. (The same bulbus showed in other roentgenograms a smooth contour.)

Figure 11 is a series of roentgenograms from a patient with cancer of the stomach deforming the duodenal bulb. The pars inferior duodeni is here filled out, and one can see very well in the area marked *a* the

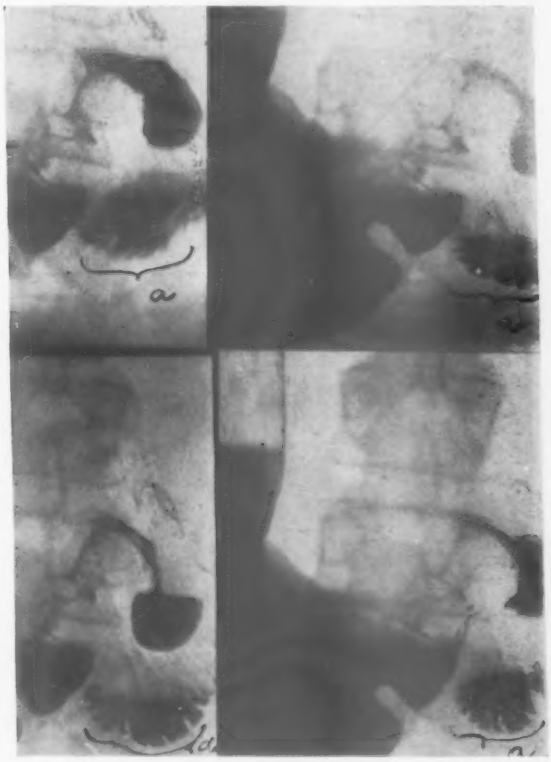

FIG. 11. A series of four roentgenograms of the folds of the mucous membrane of the inferior part of a duodenum made at intervals of about forty-five seconds.

change of the number, position, form and depth of the folds of the mucous membrane during the time of the making of the series of exposures.

An objection might be made to the effect that the fold-like elevations in the lumen, which appear in the roentgenograms and which change form and place, were not caused by the folds of the mucous membrane, but by the contraction of the muscu-

lar coat, which could possibly produce the elevations in question in the lumen through small, local contraction.

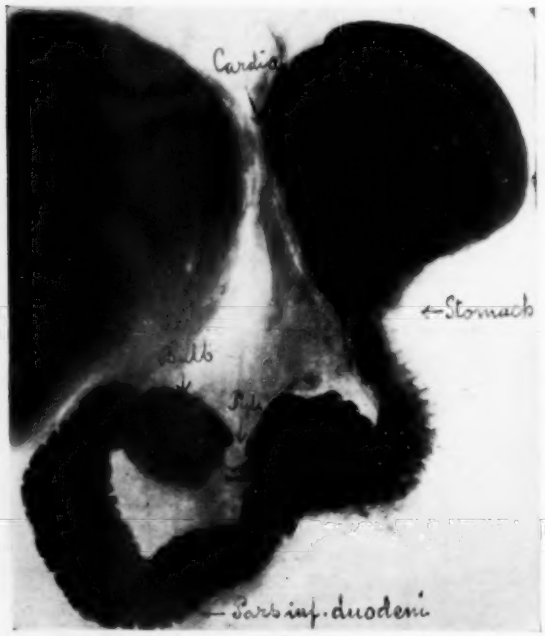

FIG. 12. A roentgenogram of the same anatomical preparation as in Figure 7.

A glance at Figure 12 will persuade you that the folded contours in the roentgenograms of the living duodenum correspond

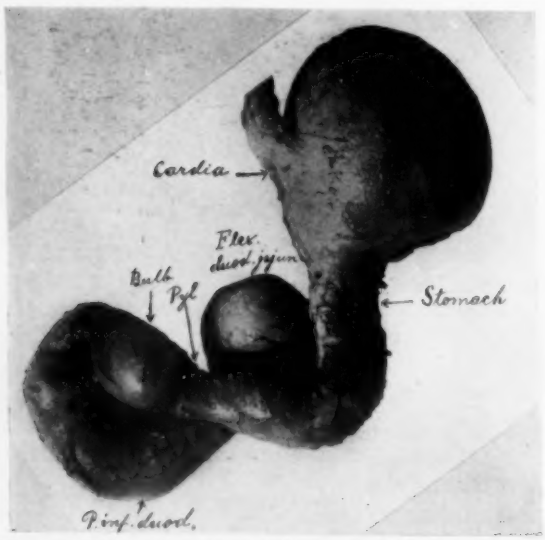

FIG. 13. The outer surface of the anatomical preparation of a duodenum which is shown in Figures 7 and 12.

with the folds of the mucous membrane of the anatomical preparation. Figure 12 shows the same anatomical preparation of the duodenum shown in Figure 7 (No. 2), but here the lumen is filled with a contrast meal.

One might be persuaded that the contours in this roentgenogram of the dead mucous membrane correspond entirely with the outlines which in the roentgenogram of the living duodenum have been interpreted as folds of the mucous membrane.

Figure 13 illustrates the outer surface of the same preparation, and shows the muscular coat smooth, and without any

FIG. 14. Anatomical preparation of the mucous membrane from a proximal loop of the jejunum.

local constrictions that are capable of causing the fine elevations in the lumen, interpreted as folds of the mucous membrane.

Figure 14 shows an anatomical preparation of the surface of the mucous membrane from a proximal loop of the jejunum. The folds are high and close together with rich, transversal folds, surrounding numerous small, digestive chambers that lead to a central lumen. This is the usual description of the jejunum.

Figure 15 demonstrates a roentgenogram of a living intestine and shows a relief of

the mucous membrane, corresponding to the previous illustration. The upper part of

FIG. 15. Roentgenogram of a proximal loop of a jejunum in a live subject, corresponding to Figure 14.

the jejunum (*A*) is divided into numerous digestive chambers, varying from the size

FIG. 16. Anatomical preparation of the mucous membrane on a loop of the jejunum immediately beside the loop shown in Figure 14.

of a hemp-seed to that of a grain of rice.

Figure 16 shows the mucous membrane in a loop of the jejunum immediately beside the former. The folds are of a different type—simple, circular, and placed at longer intervals. The folds form more or less disc-like chambers which are broadly connected through a central lumen. Figure 17 shows a corresponding roentgenogram of a patient, in whom the upper part of the jejunum (*A*) has been speedily filled up by a gastroenteroanastomosis. To be recognized are the same simple, circular folds, forming digestive chambers in the form of discs. (*V*, stomach.)

FIG. 17. Roentgenogram of a proximal loop of the jejunum, corresponding to Figure 16.

Figure 18 shows other types of the relief of the mucous membrane in the jejunum.

Special attention should be paid to the illustration marked with an arrow. The folds lap over each other similar to the lamellae of a cream separator; in this case they are directed towards the flow of the contents.

Figure 19 shows a roentgenogram of a corresponding formation in a living patient.

Some may think that the folds of the mucous membrane, in the various loops, could have a different structure. Serial

roentgenograms of living beings show, however, that the same loop of small intestines can, in a short time, entirely change the relief of its mucous membrane.

Figure 20 shows two roentgenograms of a high jejunal loop, made at an interval of one minute. The area marked *a* should be specially noted.

FIG. 18. A cross-cut of an anatomical preparation of a jejunal loop.

In the upper illustration, there are in this area a few wide, simple and deep folds. In the lower one, the relief in the same area of the mucous membrane has entirely changed. There are now numerous close-sitting, small folds, divided into transverse folds, which divide the lumen into fine, small chambers.

Figure 21 has two illustrations of ileal loops, made at an interval of ten minutes. Special attention should be paid to the loops in both, at point *b-c*.

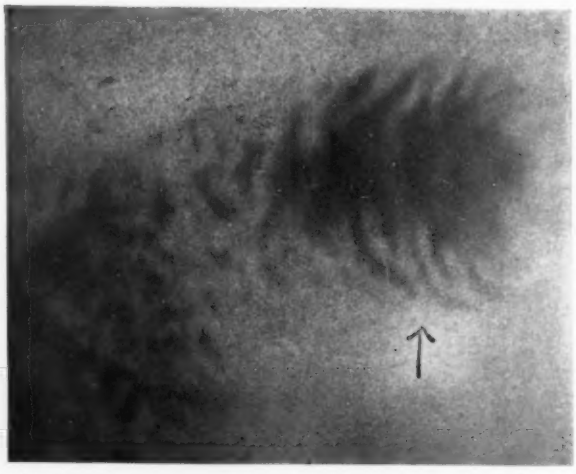

FIG. 19. Roentgenogram of a jejunal loop in a living subject, corresponding to the lower figure in Figure 18.

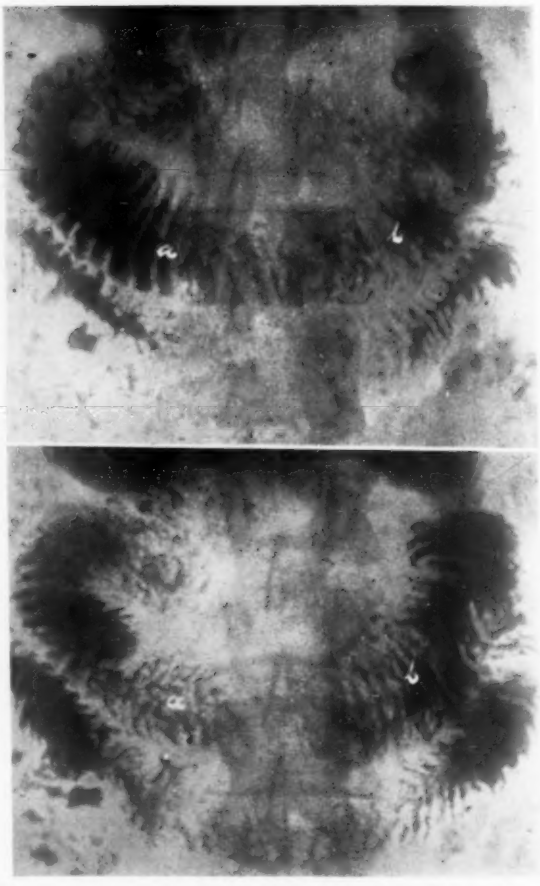

FIG. 20. Two roentgenograms of a jejunal loop in a living subject made at a one-minute interval.

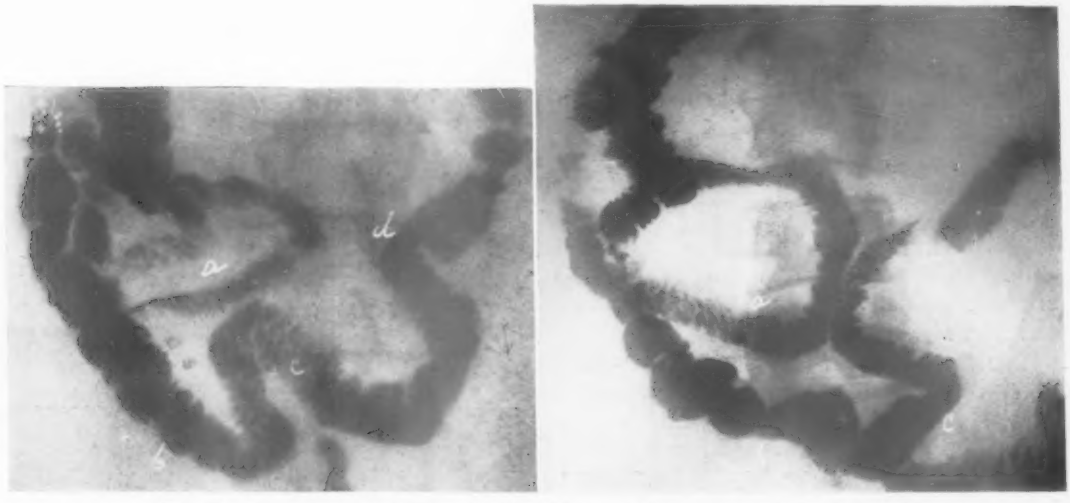

FIG. 21. Two roentgenograms of an ileal loop made at a ten-minute interval.

In the right one, this loop is divided into fine digestive chambers by close-sitting, fine, complicated folds.

In the left one, the surface of the mucous membrane of the same loop is nearly without folds. At the same time, in this illustration, a "segmentation" of this loop, according to Cannon, can be seen.

According to prevalent descriptions, it is said that the folds of the ileum are lower than the folds of the jejunum and will slowly, totally disappear in the lowest part of the ileum.

It is true that generally the ileum shows lower folds than the jejunum; but the ileum can, in every part, show a relief of the mucous membrane quite as high and quite as complicated as the jejunum.

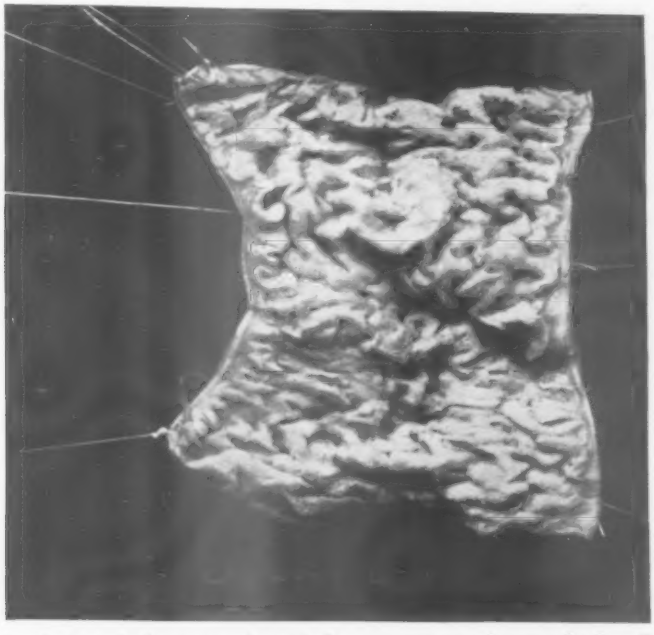

FIG. 22. Anatomical preparation of the mucous membrane of a low ileal loop.

Figure 22 shows a surface of mucous membrane from the lower part of the ileum, which shows a very high and complicated relief of the mucous membrane,

dividing the lumen into the finest digestive chambers.

Figure 23 shows a roentgenogram in which the terminal loops of ileum have been filled by a contrast clyster. In spite of their being relatively strongly dilated, these ileal loops (*A* and *B* in the illustration) show deep and close transverse folds, similar to the folds of the jejunal loop, which has been speedily filled by gastro-enteroanastomosis. (*C*, cecum; *Fs*, flexura sigmoidea; *R*, rectum.)

Figure 24 is a roentgenogram in which the terminal loop of the ileum, four hours after a contrast meal, shows fine longi-

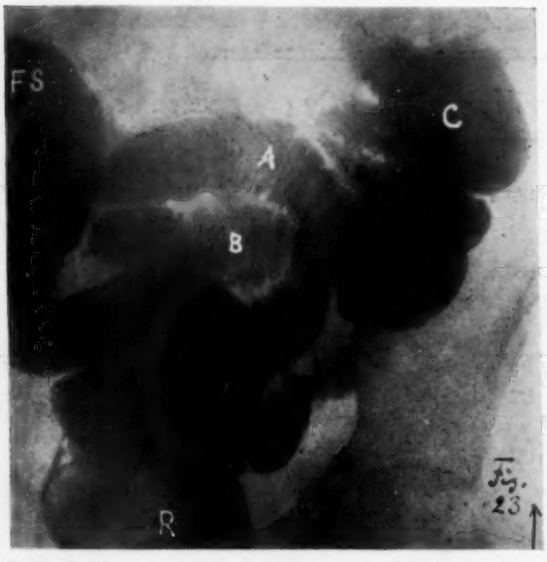

FIG. 23. Roentgenogram of the terminal loops of ileum A and B filled by a contrast clyster. C = Cecum; Fs = Flexura sigmoidea; R = rectum.

tudinal folds, while the other loops of the ileum have the ordinary smooth outlines of the mucous membrane. (*C*, cecum.)

Figure 25 shows a number of loops of small intestines, filled up four hours after a contrast meal. In this illustration there are loops of the same width, which show different forms of relief of the mucous membrane.

For instance, if comparison is made between loops *a* and *b* which have nearly the same width, *a* is nearly without folds, *b* shows a deep and finely folded outline. The conditions are the same with *g* and *f*. The loop *e* shows on one side a close folding of the mucous membrane, but on the other side is free from folds, and shows on this side segment-contractions of the muscular coat.

According to my opinion, such a formation of the folds is inexplainable by only a passive folding-in of the mucous membrane depending only on the degree of contraction of the muscular coat. An independent movement of the mucous membrane seems to me to be the only possible explanation.

Through good fortune, I have been in a position to add the final link to the chain of evidence, through direct observations

FIG. 24. Roentgenogram of the terminal loop of the ileum four hours after a contrast meal. C = Cecum.

on a living mucous membrane. A fifteen-year-old boy, who had an ileal fistula, came to me for roentgen examination. He had an exposed mucous membrane about 3.5 × 4 cm. in size. Immediately after having taken away the compress, I saw the folds of the mucous membrane change form and position, without the exposed surface of the intestine having visibly changed size or form, and independent of the rhythmical contractions of the muscular coat that passed over the muscular coat about eight in a minute.

I was in a position to take twelve photographs of the surface of the mucous membrane, in one hour's time. Figure 26 shows six of these pictures. A compari-

son between these different phases of movement will, better than words, illustrate the changing of the relief of the mucous membrane.

Comparison should be made between the areas marked with a cross on the different pictures. For instance, in phase 1, this mucous membrane area is nearly without folds; in the phases 2, 5, 9 and 10, it shows mostly transverse folds, changing in form and position, and in phase 12, fine vertical folds.

In the colon the genuine folds of the mucous membrane have aroused little interest, as the plicae semilunares, originated by the contractions of the muscular coat, have attracted all the attention. A study of the mucous membrane in anatomical preparations hardened shortly after death, as well as a close study of the roentgenograms, show, however, that the genuine folds of the mucous membrane play a very important part in the formation of the colonic lumen.

Figure 27 shows a part of the outer surface of a piece of flexura lienalis and the corresponding surface of the mucous membrane from the same preparation. A comparison between the two pictures will show you that the folds of the mucous membrane join to form ridges which bend into the lumen and play an important part in the modeling of the inner surface of a contracted colon.

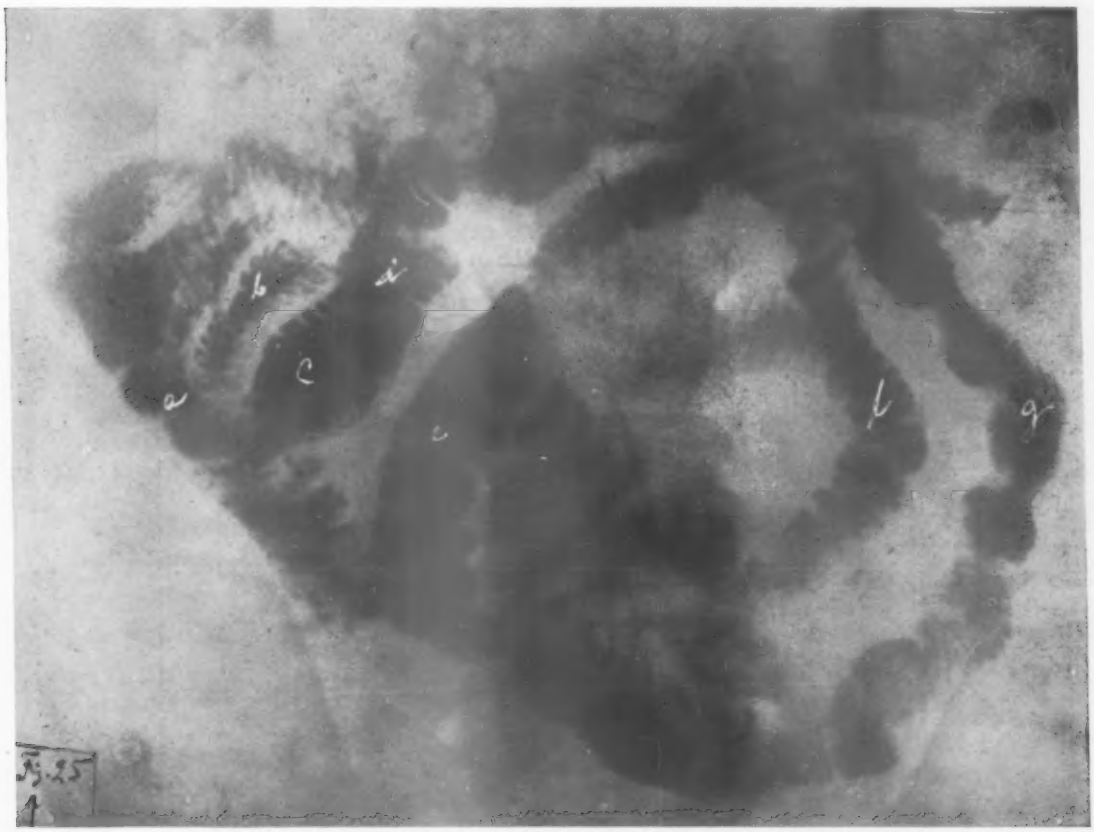

FIG. 25. Loops of small intestines filled up four hours after a contrast meal.

Figure 28 also gives a clear idea of the great importance of the folds of the mucous membrane in forming septa in the colon.

In this picture, it is possible to look into the cavity of the flexura hepatica, and get an idea of the deep, circular diaphragm which is here formed by the high folds of the mucous membrane.

Figure 29 shows three transversal sections of a strongly contracted flexura sigmoidea. In the upper picture a muscular septum, originated from a transverse contraction of the muscular coat, fills up the lower half of the lumen. But, on the other

hand, the folds of the mucous membrane fill up the cavity in such a way that it is possible to misconstrue them as a transverse section of the jejunum.

membrane, take for granted that the outlines of the roentgenogram, to a great degree, are defined by the relief of the mucous membrane. For instance, the high

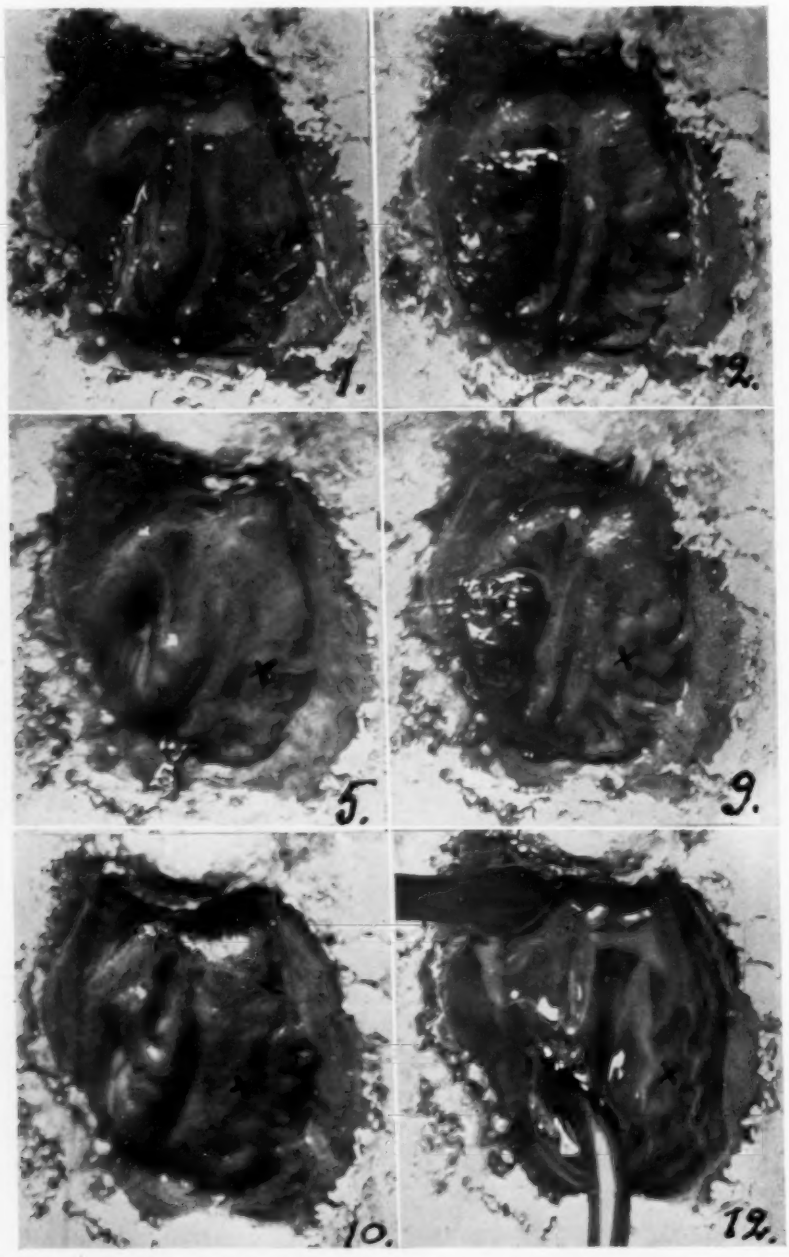

FIG. 26. A series of six illustrations of the living mucous membrane, exposed in an ileal fistula.

Examining an ordinary roentgenogram of the colon, as in Figure 30, we must, with our knowledge of the exterior form of the colon and of the relief of the mucous

formed elevations (*K*) in the lumen are caused by the ridges of the mucous membrane bending into the cavity, and the smooth, rounded form of plicae semilunares

(*S*) is, without doubt, caused from the folds of the mucous membrane on the crest of the plicae.

I was also in a position to observe an exposed surface of a mucous membrane from the colon descendens, in a prolapse of the colon in a colostomy, and could thereby ascertain that, in general, a richer forming of the folds appeared together with an increased contraction of the muscular coat, but that the mucous membrane even with very high folding could freely be moved against the underlying muscular coat; that a change of the folds of the mucous membrane as to the number, position and form took place, independent of the contraction of the muscular coat, and that purely local ridges of the mucous membrane have been formed without a corresponding local contraction of the muscular coat.

It should, therefore, be without doubt that the folds of the mucous membrane, of the colon, as well as those of the stomach, duodenum and small intestines, are not modeled by a contraction of the muscular coat only, but by autonomous appropriate movements of the mucous membrane.

Although the relief of the mucous membrane can vary in a high degree in every part of the digestive canal, it is clear, however, that the mucous membrane in these parts has a certain tendency to form contraction-forms, typical for each part. For instance, the mucous membrane forms in the lesser curvature of the stomach; and even with the greatest shortening, there are no transversal folds, but longitudinal folds or a mammillated surface. The jejunum has a greater tendency to form a high and complicated relief of mucous membrane than the ileum, and the relief of the mucous membrane in bulbus duodeni is of a different type from that of the folds in the other intestines.

Where do we then find the motor forces of the mucous membrane?

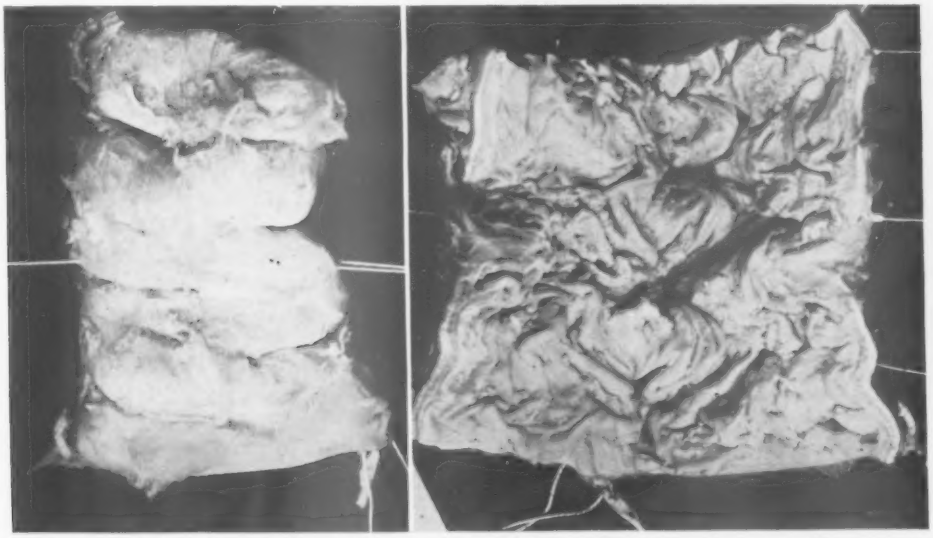

FIG. 27*a*. The outer surface of an anatomical preparation of a part of the splenic flexure.

FIG. 27*b*. The mucous membrane of the same part of the splenic flexure.

The muscular coat (muscularis propria) models the exterior form and width of the digestive tube, but has no mechanical qualifications for a localized and individual folding of the mucous membrane, this membrane being freely movable against it. The muscularis mucosae forms the special contractible organ of the mucous membrane which, being attached to this one and to the submucous layer, is able to displace the mucous membrane in all directions by means of transversal, longitudinal and oblique fibers.

The mass of the mucous membrane, and, consequently, the volume of its folds, ought to be regulated by variation of the filling of the vessels, while number, posi-

FIG. 28. Anatomical preparation of the mucous surface of the hepatic flexure.

FIG. 29. Transversal sections of a strongly contracted sigmoid colon.

FIG. 30. Roentgenogram of the left part of a normal colon after contrast meal.

FIG. 31. Roentgenogram of a strongly contracted sigmoid colon filled by a contrast clyster. SC = Sigmoid colon.

tion and form of the folds are determined by the muscular system in the muscularis mucosae.

The forming of the high and close folding of the mucous membrane may occur more easily with a simultaneous contraction of the muscular coat (membrana propria), but a definite degree of contraction of the muscular coat does not produce a definite corresponding relief of the mucous membrane; on the contrary, a stage of contraction, producing a certain width of the muscular tube, can be associated with a relief of the mucous membrane varying from an even surface to a very complicated folding.

According to the present general opinion about the anatomical nature of the folds of the mucous membrane, an exclusively passive function is attributed to them, the folds only being supposed to have the purpose of enlarging the digestive surface and of preventing a too rapid flow of the intestinal contents. The knowledge that the folds of the mucous membrane do not consist of passive structures, but represent a momentary state of movement, must apparently involve a new appreciation of their function.

The whole rigid world of folds and furrows becomes alive and proves to be formed by independent motor forces which may be of great importance for the mechanical regulation of the digestion. It is apparent that the complicated relief of the intestinal mucous membrane not only forms a passive depository for digestion and resorption of the food, but also constitutes a mechanism with a subtle and wonderful organization for regulation of the chemistry of the digestion.

The muscular tube of the digestive tract and the special motor mechanism of the mucous membrane collaborate in the mechanism of digestion.

The movements of the muscular coat determine the rough division and the large displacements of the contents of the stomach and the intestines. The movements of the mucous membrane produce an extremely differentiated distribution and restraining of the food in digestive chambers of varying form and size, and procure the fine regulation of the current by the passage of the contents in the alimentary canal.

The rôle that disturbances of the motor mechanism of the mucous membrane may be playing in the pathology of the alimentary tract has not yet been investigated and great difficulties may occur in working out this problem.

At any rate, it is necessary, by studying the pathology of the alimentary tract, and, especially, by interpreting the roentgenograms of the intestines, to emphasize that the relief of the mucous membrane, not being a fixed structure, represents a state of autonomous movement.

Great experience and a thorough comparative investigation are necessary before we are able to distinguish the pathological types of the relief from the normal ones, and to separate the outlines formed by defects or infiltrations of the intestinal wall from the relief of a contracted mucous membrane. Probably new fields will be opened here for medical research.

DISCUSSION ON PAPERS OF DRS. BARCLAY, ALVAREZ AND FORSSELL*

DR. CASE. I feel, personally, much profited by hearing these entertaining and instructive papers. I feel very incompetent to offer any discussion on them. It is new light so far as I am concerned. I am particularly interested in Dr. Alvarez' work, because we all have had the experience in doing fluoroscopy of the chest and of seeing fibrillation and heart-block which are observed so nicely on the screen. I shall look forward with a great deal of interest to every development in this research.

It is also very interesting to note Dr. Forssell's work concerning the mucous membrane movements, which, in a measure, is confirmatory of some observations brought out by Cole.

* Papers read (those of Drs. Barclay and Forssell by title) at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., May 22–23, 1922. The paper by Dr. Barclay appeared in December, that by Dr. Alvarez in January, and that by Dr. Forssell precedes this discussion.

We are quite prepared to accept the propositions of both of these gentlemen and shall look forward to further interesting data along this line.

We are indebted also to Dr. Barclay for his contribution to the topic for this hour's discussion. I only regret that our distinguished foreign essayists were not able to be here in person.

Dr. Pirie. I think the society is to be congratulated on having such a paper as we have listened to. It is one of those things which we need so badly. We began the examination of the stomach long ago, and we have not reached fundamental principles as yet.

Dr. Alvarez mentioned the fact that the stomach responds to the duodenal rhythm. I have two slides which illustrate his remark. They are serial pictures of the stomach and duodenum, showing how the distal part of the duodenum contracts when the peristaltic wave in the stomach is approaching the pylorus. One would expect that the peristaltic wave in the stomach might be continued through the pylorus into the duodenum, but it is not so. A wave of peristalsis is seen to rise in the middle of the cap before the peristaltic wave in the stomach reaches the pylorus.

Dr. Moore. My inability and incompetence are greater than those of Dr. Case to discuss the details of any subject of this kind. Certainly those of us who have had the honor and pleasure of hearing Dr. Alvarez before knew we were going to be enlightened.

The society should be congratulated on having two such contributions from two prominent roentgenologists of Europe.

One of the weakest links in the chain of roentgenology today is the absence of any literature or definite knowledge of roentgen physiology, if it might be so expressed.

Dr. Alvarez (closing discussion). Dr. Forssell's work interests me because a good deal of work has been published of late in physiological journals on the contractions of the muscularis mucosae. The study of such puckerings may easily be of value, especially in diagnosing the presence of small ulcers on the anterior or posterior walls of the stomach. They show up well when there is just enough barium present to demonstrate the folds of mucous membrane.

Dr. Pirie's observations interest me very much because most of our graphic records show that the rush waves down the bowel generally originate in tonus contractions of the upper duodenum, and such tonus contractions seem to be due to the arrival of a wave of some kind, which travels out well ahead of the peristaltic wave in the stomach.

IMPORTANCE OF INDIRECT ROENTGEN FINDINGS IN CHRONIC INFECTION OF THE BILIARY DUCTS AND GALL-BLADDER*

BY M. P. BURNHAM, M.D.

SAN FRANCISCO, CALIFORNIA

HERETOFORE the roentgenologist has depended almost entirely upon the presence of calculi in the gall-bladder in the study of biliary tract infection for his findings. More recently, George has shown the possibility and importance of demonstration of the diseased gall-bladder itself, and has called attention to other manifestations of infection.

Chronic infection of the liver, bile ducts, and gall-bladder constitutes an entity, the characteristic feature of which is its chronic course. Calculus formation, duct blockage, etc., represent lesions of long-standing infection.

The present-day surgical literature stresses the fact of difficulty of recognition of even quite marked inflammation in gall-bladder by inspection and palpation of the organ at operation, the symptoms in these cases being of such severity as to have demanded operative interference.

This difficulty in recognition of disease processes of the biliary system with the abdomen open will explain the limitations of the direct roentgen findings.

The pathology of infection in liver and biliary system is a generalized one, in ducts and gall-bladder an interstitial process and not as formerly thought, largely made up of infection of contents of these organs. The biliary ducts are of narrow caliber, often anomalous in course, and offer difficulty to the passage of bile readily enough, when as a result of the infection the walls are thickened and the bile increased in density, the end result being stasis.

One of the three lymphatic systems of liver is in close relation with both cystic and common ducts, especially the latter, as it traverses the gastrohepatic omentum. These structures, in turn, bear a close relation with the distal aspect of the duodenal bulb and upper part of the second portion of the duodenum, being situated at that point posteriorly and with the medial aspect of the second portion

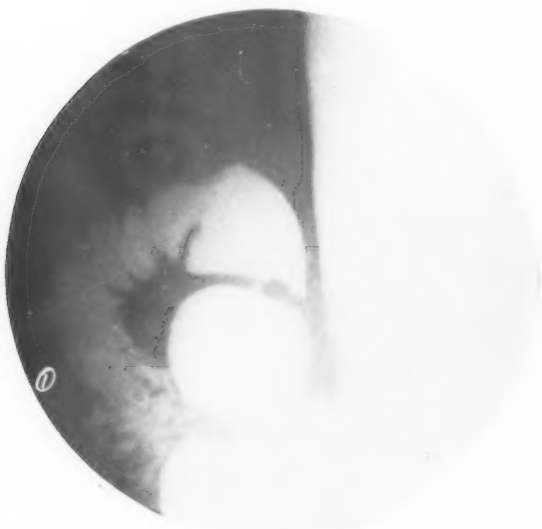

FIG. 1. Normal right oblique prone position.

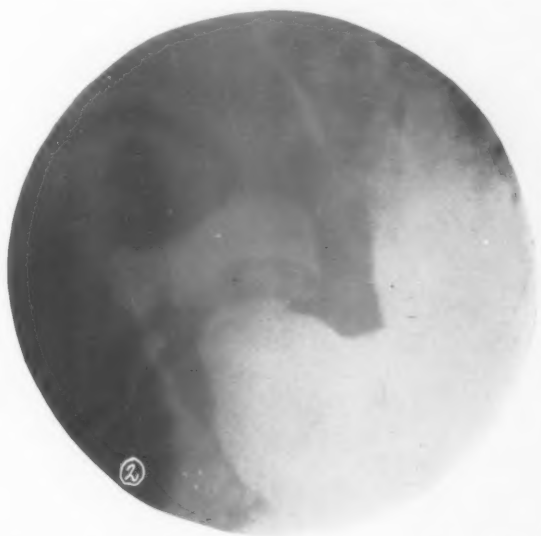

FIG. 2. Bulb deformity; angulation second portion of duodenum.

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

lower down. In this region surgeons frequently at operation encounter distinct evidences of pathology about the ducts and neck of the gall-bladder when the fundus itself appears normal. Moreover, in attempting to mobilize the ducts and the neck of the gall-bladder and later in tying off, distinct evidence both of fibrosis of the ducts and the tissues about the ducts is demonstrable. Examination of the gall-bladder wall in these cases, on removal, gives definite evidence of infection. It has seemed to us probable that these earlier changes in and about the ducts and neck of the gall-bladder are associated with the beginning symptomatology presented by

The evidence itself may be divided into two groups: (1) Changes of form and position seen in the first and second portions of the duodenum, and (2) variations in the normal gastric physiology.

A few words regarding the technique of the examination: The ordinary opaque buttermilk meal is used, and we are accustomed to re-examine on the following day, utilizing an aqueous opaque meal for the gastrointestinal examination. The position of the patient in which the investigation is carried out is quite important. The standing position is not used on account of the drag of viscera under examination. The prone position also, as a result of pressure

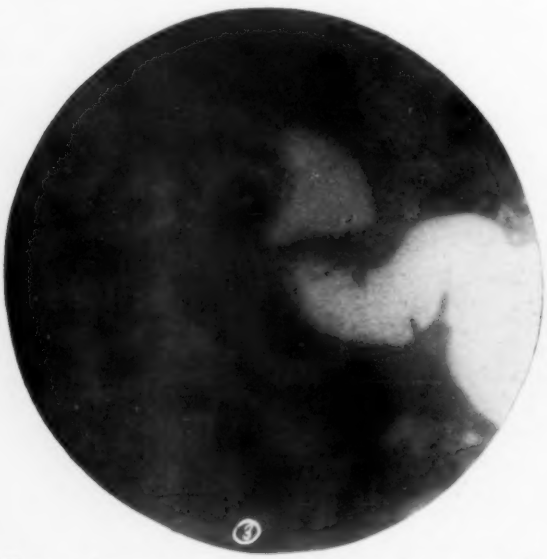

FIG. 3. Antrum spasm. Bulb indentation; angulation second portion.

FIG. 4. Bulb deformity; angulation second portion of duodenum.

cases of chronic infection of the biliary tract. More and more surgery is being instituted in these non-calculus stages of duct and gall-bladder inflammation.

To limit our studies, therefore, to calculus demonstration by roentgen methods, even though they might be shown in 100 per cent of the cases when present, would highly restrict the usefulness of the examination.

However, the so-called indirect manifestations of duct and gall-bladder inflammation have been, in our hands, during the past few years, of increasing value in diagnosis. I feel that this evidence should be obtained independent of historical data.

and overlapping of the various organs under study, is open to objection. We have found, by placing the patient in the prone position and by the use of the fluoroscope, turning the body toward the right lateral position, there appears at a certain angle, dependent on the individual habitus of the patient under examination, a position in which a clear profile view of the pyloric section and first and second portions of the duodenum is obtainable. In this position, any deformity of these sections can be best studied uninfluenced by pressure or traction from a normal source. In this position, the distal aspect of the bulb and the angle made as the

bulb merges into the second portion are brought out in absolute clearness, the normal then being easy to establish. It is in these sections that we look for deformities, the result of biliary system pathology.

The angle of this right oblique position cannot be foretold in any case. A few degrees either way from it will militate seriously against its usefulness. It may be said that approximately 5 per cent of patients pass clear to the right lateral position. These are patients of sthenic habitus.

The first class of evidence, namely, that of change of form and relation in the first and second portions of the duodenum, and course of the second portion in the duodenum are quite as characteristic as the indentations in the bulb, in our experience.

The second class of evidence, namely, that of changes in the normal gastric physiology, is most interesting, but not nearly as decisive in character as changes noted in duodenum. It may be stated that the normal stomach accepts the liquid opaque meal, holding it in the form of a column of about equal width throughout, the pyloric sphincter closing, preventing its discharge into the intestine, and the cardiac sphincter closing, preventing regurgitation of the stomach contents into the esophagus.

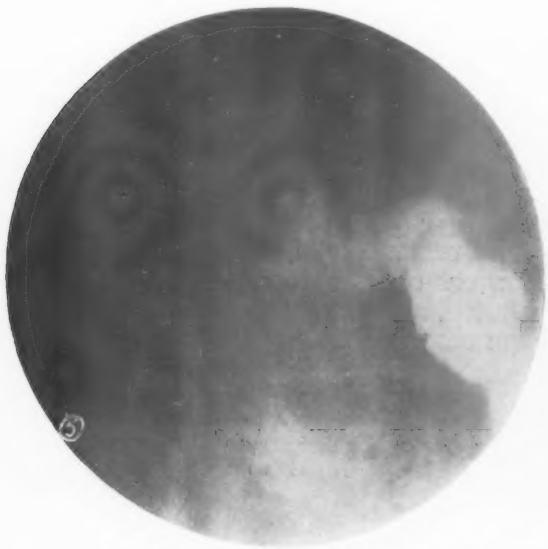

FIG. 5. Angulation second portion of duodenum.

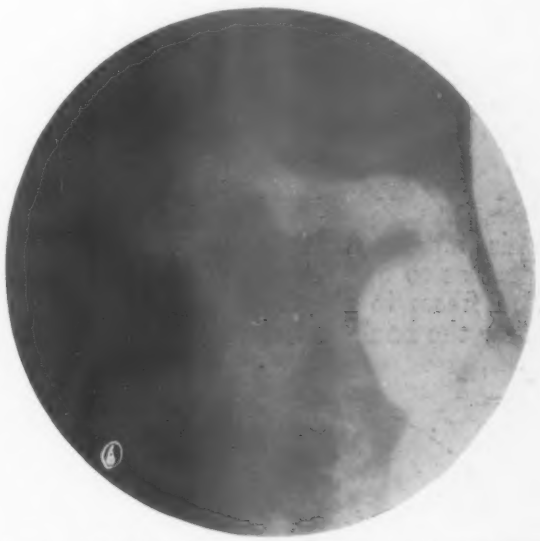

FIG. 6. Bulb deformity; angulation second portion of duodenum.

due to pressure mainly, although adhesion fixtures cannot be excluded as a cause, consists of clean-cut indentations of the duodenal bulb, crescentic deformities, usually seen on the lateral aspect of the bulb or on the inferior aspect; also irregular deformities of the bulb, not of the crescentic type, and distortion in the course of the descending duodenum amounting in many cases to very great angulation. These gall-bladder pressure deformities are, in a general way, much alike in all cases, changing as to the particular point in the duodenum at which the pressure is most prominently seen, dependent on the pathology present in the individual case. The angulations in the

There is frequently seen, in cases of gall-bladder and bile duct infection, a narrowing in the pyloric end of the stomach produced by spasm of the wall, the stomach taking the form of a narrow-caliber tube. In other cases is seen a conical-shaped pyloric section, the result of spasm, with apex at the sphincter. This spasm appears immediately on taking a meal, and may persist for considerable periods of time. When the peristalsis is established, it is noted that the waves begin far back on the curvatures and traverse the stomach slowly, often failing to reach the pyloric sphincter. At no time has the antrum a globular shape such as we see normally.

This spasm of the pyloric section increases the intragastric tension and, I believe, is the cause of the sensation of the fullness and distention, of which patients complain.

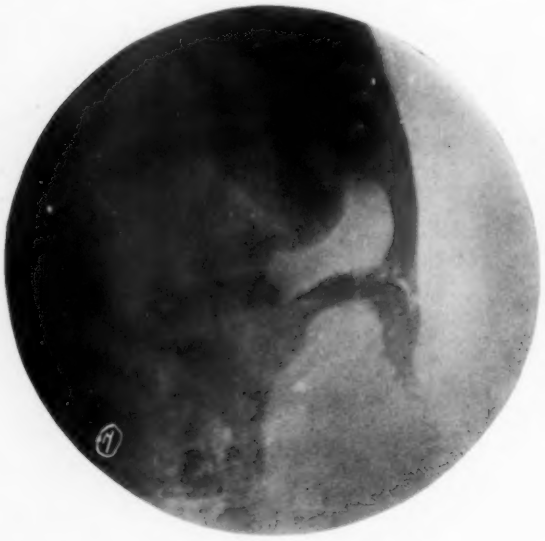

FIG. 7. Bulb indentation.

This increased tension may become so great as to overcome the normal constriction fibers in the cardiac sphincter, and allow the back-flow of small or even large amounts of the meal into the esophagus. The small amounts, in our experience, are usually returned at once to the stomach by peristalsis in the lower segment of the esophagus. It has appeared to us that in some cases the loss of the sphincter control mechanism has passed a point where intragastric tension may no longer be the cause of its occurrence, but that an actual inhibition of the constriction fibers has resulted, and the meal will flow to and fro from stomach to esophagus with little or no retardation at the sphincter. When this condition of complete, or nearly complete, divulsion of the cardiac sphincter is seen, it is necessary to exclude, as a cause for it,

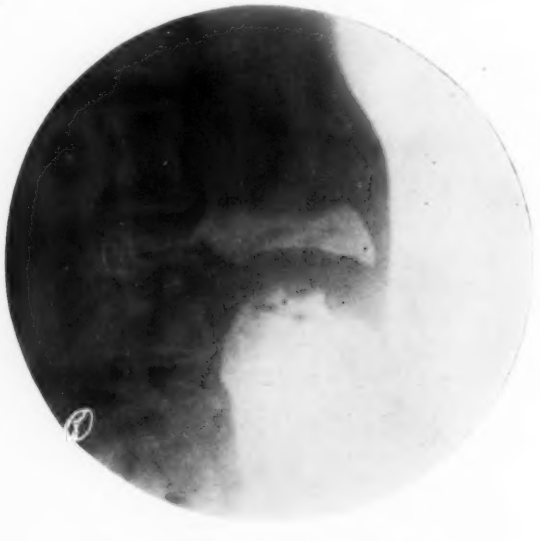

FIG. 8. Bulb deformity, angulation.

FIG. 9. Bulb deformity, angulation.

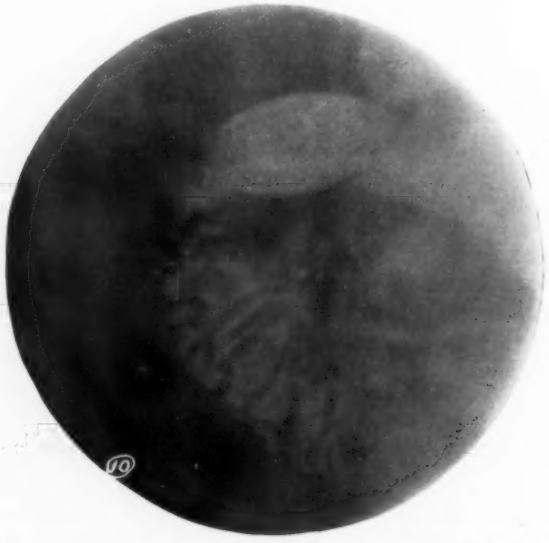

FIG. 10. Deformity on medial aspect, second portion.

any organic lesion of the gastrointestinal tract which may cause the condition.

Pyloric spasm of the type described is more commonly seen than the sphincter change at the cardia.

Of the two classes of indirect evidence, that of deformities in the two portions of the duodenum is of far greater importance than that made up of gastric physiological abnormalities. It has seemed to us, however, that the disorders of physiology may appear before any of the findings brought about by pressure or fixation in the duodenum.

We have made use of these indirect findings as an aid in the interpretation of doubtful demonstration of the gall-bladder on films. If the gall-bladder region contains a contour line in itself not determinate, it is given much greater weight in the final summing up of all available data, if attended by these indirect manifestations.

In differential diagnosis, the presence of abnormal peritoneal bands has been confusing in some cases. In a general way, however, these structures, as shown by Cole in a paper read before this society last year, have distinctive features quite different from those obtained due to lesions of the biliary system.

Several cases of ulcer of the duodenum with old perforation, resulting in fixation of bulb and irregularity of contour not of the usual type of that of ulcer, have been seen, in which it was not possible to exclude a gall-bladder lesion, the primary diagnosis being ulcer. At operation these cases have been found to be free from evidence of gall-bladder infection.

Indirect findings have made it possible to show frequently the presence of both ulcer and gall-bladder pathology in the same case. Recognition of the gall-bladder lesion, not uncommonly associated with both pre- and post-pyloric ulcer, but commonly not found by the roentgenologist, allows of consideration by the surgeon before operation, and often ends in a more orderly method of surgical attack.

In conclusion, I would emphasize the fact of the importance of the indirect roentgen evidence in the study of the earlier stages of biliary infection. I believe also that its importance at any stage far outweighs that of the direct findings.

DISCUSSION

Dr. George. It is a great personal satisfaction, both to Dr. Leonard and myself, to know that Dr. Burnham has carried on this work and has not only substantiated what we have tried to bring out in the past, but has gone a little further by emphasizing the secondary or indirect signs which determine more accurately pathology of the gall-bladder. The more we do of this work the more we realize that it is a relatively simple problem. As you all know, we have attempted to make visible the gall-bladder, and we still think that if we can accomplish it, the gall-bladder is pathological; no one has proven to the contrary so far.

In our efforts to make visible the gall-bladder we have come to depend on other signs, the same signs, practically, that Dr. Burnham has emphasized today. In the last year, especially with the use of the Potter-Bucky diaphragm, we have found secondary changes very constant. This, perhaps, we have overlooked earlier in our work, for we did not in the past attach the significance to these changes which we do at present.

As we go over this work, we find that the pathological gall-bladder almost invariably shows an impression on some portion of the stomach or duodenum, or changes in the second portion of the duodenum. The question has come up time and again why this should be.

Some of you have probably had the same experience that we have with surgeons who ask why should not a normal gall-bladder show, as we claim the pathological gall-bladder will, against the stomach, or first or second portions of the duodenum. If you ask them in turn for their diagnostic sign or signs, or what to them means a normal gall-bladder without opening it, you invariably have the reply that the gall-bladder was found easily compressible, or contents expressible without difficulty; that is, as far as palpation is concerned.

The reason, it seems to us, that the pathological gall-bladder shows this outline on the duodenum and other portions of the gastric tract is that the tension within the gall-bladder is greater than in the normal, and that it is greater than the amount of bismuth that passes around it. If this is the cause, then there must be considerable tension to accomplish this result.

In the exhibit which we have made at this meeting, we have chosen the most characteristic examples of pressure defects upon the various portions of the stomach and duodenum. There is one point in diagnosis which seems not so much a question of pressure defect, as we have

tried to explain it, due to the gall-bladder, but rather that there is a concave body which is in contact with the stomach or duodenum, and produces at the point of pressure or contact a "half-shadow." This visualization means a concave surface that must produce this change. As you will see in every instance where the gall-bladder is actually in contact with the stomach or duodenum, there is a difference in shade or density of the bismuth mass immediately at the point of contact, and it takes only a moderate amount of imagination to visualize that this is due to a globular mass, causing this pressure.

Again, we are, naturally, with the experience that we have had, impressed by the normal appearance of the stomach and duodenum, first and second portions. Unfortunately, or, perhaps, fortunately, both of us, Dr. Leonard and I, being more or less single-tracked in our ideas, have carried on our gastro-intestinal examinations in exactly the same way for the last ten years. We have never changed the meal in any way, or the technique, or the time of examination, and in no instance have we ever attempted the double meal as a method.

Taking the number of cases that we have done in the past, we very quickly with our technique can determine, and, we think, accurately, the normal, anatomical position of the duodenum; and any variation from this, where the second portion of the duodenum seems to be at right angles to its normal position, immediately opens the possibility or probability of the cause of this being adhesions arising from or about the gall-bladder. This is one of the common signs, indirectly, of gall-bladder disease. It is practically accepted by all pathologists that adhesions arising from the gall-bladder, or in any way connected with the gall-bladder, are due to disease within the gall-bladder, either past or present. This is a very definite sign.

These signs may not necessarily be found in one position. Sometimes they are found entirely in the anteroposterior position, and at other times, only in the lateral position. We have found, by talking with various roentgenologists, that very few attempt the true lateral position routinely. In every case we do as many laterals as we do the other positions, and it is probably the most important position, everything considered.

Depending, as we do, mainly on films for our evidence of gall-bladder disease, it is possible that in omitting routine fluoroscopic examinations of the stomach, we are overlooking some of these extra signs that Dr. Burnham has so clearly brought out in his paper, especially spasm. Carman first mentioned spasm to us, and after a long time of searching for evidence of this spasm, we found one case which not only showed gall-stones, but showed the characteristic changes in the antrum of the stomach that Carman mentions.

We have termed these pressure signs on the stomach and duodenum as indirect signs. As a matter of fact, they should be called direct signs, or at least, secondary, and spasm is unquestionably a secondary problem. Unless one has had a good deal of experience with the normal and with disease of other portions of the gastrointestinal tract that do produce spasm, one may be led astray, unless extremely cautious, in using spasm as an important sign. I think Dr. Burnham from his experience is in a position to emphasize this sign even more than we.

It has been a great personal satisfaction to have heard Dr. Burnham's paper because it has been instructive, and I am sure that my coming visit to Dr. Burnham in San Francisco will emphasize more strongly even than he has today the importance of these signs that he has mentioned to us.

Dr. Case. I have enjoyed Dr. Burnham's paper very much and have enjoyed still more the splendid roentgenograms which he has set up in the Scientific Exhibit. I have been very much profited by the further contribution to this subject which he has made.

With Dr. George and his colleagues, I have for a number of years held that the shadow of the gall-bladder, when definitely determined upon the roentgenogram, was a sign of a pathological gall-bladder. On several occasions, in my surgical work on patients whose roentgen examinations showed an indisputable gall-bladder outline, I have found the gall-bladder to be easily compressible and the contents easily expressible; the gall-bladder wall being thin, with no enlarged glands about the cystic or common ducts, and with no pericholecystic adhesions. On account of the history, I felt that I was justified in removing the gall-bladder in these cases; and when the gall-bladder was later opened, it proved to be definitely diseased. I would like to show you slides of a number of such gall-bladders, showing, in one instance, 100 or more grains of small black biliary sand; in several other instances, papillomata of the gall-bladder which were easily made out with the naked eye. We have also made bacteriological studies of the bile from the gall-bladder and cultures of macerated portions of the mucosa of the gall-bladder from both fundus and neck in a number of these cases. I am frank to say that I have seen a fair number of cases where, in spite of very distinct delineation of the gall-bladder on the roent-

genogram, I have not felt justified in removing the gall-bladder. I feel that we can only go so far as to say that the distinct outline of the gall-bladder in the roentgenogram suggests pathological gall-bladder and may be considered as a contribution to the evidence going to condemn such a gall-bladder.

I feel that it is very important to emphasize that before making a diagnosis of visualized gall-bladder, we must identify the shadow of the right kidney and the shadow of the lower edge of the liver; the gall-bladder outline must be a third shadow. I think a great many kidney outlines have been mistaken for enlarged gall-bladders.

Another point is the question of indentation on the duodenum, which is presumed to be made by a distended gall-bladder. I feel that this does not *prove* gall-bladder pathology; it only suggests it. I am perfectly certain that the normal gall-bladder can make such indentation. I think we may say only this: that it contributes to the diagnosis, but that of itself it certainly is not pathognomonic.

We have made a summary of something over 350 consecutive cases of gall-bladder disease where the gall-bladder was either removed or drained surgically; the operative findings have been compared with the findings of the direct or indirect *x*-ray signs. We were able to make an *x*-ray diagnosis of gall-stones in 32 per cent of the cases in which stones were found at operation; but the indirect signs such as I have been employing for years, and such as have been outlined by Dr. Burnham in his excellent paper today, were present in 88 per cent; so that I feel that the indirect *x*-ray method is certainly a very dependable method of contributing to gall-bladder diagnosis.

After long experience in this thing, and after considerable effort to prove that the gall-bladder when visualized is always pathological, I am free to state my conviction that this is not always true, and that the duodenal indentation may be made by a temporarily distended normal gall-bladder. The gall-bladder is normally distended when one holds the breath, and usually these roentgenograms are made while the breath is held.

Dr. Alvarez. I want to congratulate Dr. Burnham on his paper, which, I think, marks a definite advance in our knowledge of the subject. His plates are beautiful and they fill me with the hope that we may be able to diagnose more of these diseased gall-bladders. I still, however, cannot quite accept some of his conclusions.

I do not see how a roentgenologist who takes no history and who does not follow up the patient after operation can tell whether these indenting gall-bladders are diseased or not. I take a most careful history, I make a physical examination, I screen the patient and study the plates. Then, if the patient is operated upon, I see the gall-bladder, I take it to our University bacteriologist for cultures from the bile and the ground-up wall, and I study sections with the pathologist. Later I follow the patient up to see if there is relief from symptoms. I do not see how any one can have a right to strong opinions until he does that sort of thing. What I have learned is that a symptom-producing gall-bladder with its wall full of bacteria is often soft and absolutely normal to the touch. I agree with Dr. Judd of the Mayo Clinic that in order to give these patients relief we must often remove the organ, simply because the history points so strongly in its direction. If we cannot recognize many of these diseased gall-bladders by visual and tactile examination, how can we ever hope to recognize them roentgenographically?

Dr. Moore. I would like to congratulate the essayist on his paper.

We have done, I am sorry to say, little gall-bladder work in depending to any degree on direct or indirect evidence. I would like to ask Dr. Burnham in regard to indirect evidence—spasm; whether he has seen a six-hour retention in the stomach as the result of gall-bladder disease, and whether or not these deformities are influenced by antispasmodics, such as belladonna.

We feel that the gall-bladder is a big part of gastrointestinal diagnosis, not so much from the roentgenological standpoint as from the general clinical picture of digestive disturbances.

I was glad to hear Dr. Alvarez mention the difficulty of determining what constituted pathology of the gall-bladder while it was in the patient. It seems to me that in these cases the attitude is pretty well expressed by what I recently heard one surgeon say: that in exploring a case in which the diagnosis had been doubtful, and in which the examination was doubtful, the appendix might be regarded as the first-line trench—first the appendix and then the gall-bladder.

It is remarkable to me, and a source of extreme gratification in following cases, to find what extreme relief some of these digestive disturbance cases obtain by removal of the gall-bladder.

If we can obtain definite or other signs in the duodenal bulb, and if the gall-bladder will produce these signs, then the roentgenologist is going to offer assistance to the general diagnostician and surgeon.

Dr. Hickey. I would like to ask Dr. Burnham whether he extended his studies

toward secondary signs with regard to the colon, whether he found any deformity in connection with the hepatic flexure and whether he finds a tendency to stasis in the cecum.

DR. BURNHAM (closing discussion). I have not noted anything in the colon as to stasis. I have not gotten any help out of the six-hour retention and really do not recall whether or not it occurs at all frequently.

The title of my paper was meant to express what I was trying to get at. I have been unable to demonstrate stones with any satisfaction except when a man would say, "I know this case has stones." In many veteran cases of this sort, stones can be made out by us.

Since we have undertaken this work, the visits to the operating-room have become a great pleasure, and I have seen as many as 3 cases of non-calculus cholecystitis surgically treated in a morning's work.

I have been interested in the clinical check, although I have never been able to follow my cases closely, but repeatedly I have gotten in touch with patients six months after operation, and have been surprised at the relief obtained from removal of the gall-bladder.

The point I wish to emphasize is the importance of making investigations and putting down findings in a clear-cut way, in order to help the man who is consulted by the patient with obscure symptoms.

AN X-RAY STUDY OF THE ABSORPTION OF TUBERCULOUS EXUDATE WITHIN THE LUNG*

BY KENNON DUNHAM, M.D., AND VERA V. NORTON, M.D.

Cincinnati Tuberculosis Sanatorium

CINCINNATI, OHIO

THIS is primarily an *x*-ray study. To us it conclusively demonstrates that tuberculous exudates are frequently absorbed. Many of the lesions observed have been tuberculous caseous bronchopneumonia in far advanced cases. We believe that absorption is even more common in early apical lesions, but such cases are uncommon in the Cincinnati Tuberculosis Sanatorium. If such absorption were compared with that following the consolidation of a frank pneumonia, it would be called slight and infrequent. We have limited this report to cases observed during the single year, July, 1921, to July, 1922. Absorption of tuberculous exudate was noted in 59 cases out of a total of 489, or more than 12 per cent of those examined. This was a striking observation to us, as it was neither slight nor infrequent.

The generally accepted idea of the healing of tuberculosis is thus expressed by Delafield and Prudden: "Small foci of tuberculous inflammation which are called miliary tubercles may, as we shall see later, extend and coalesce so that with more or less exudative pneumonia, large areas of the lung may become consolidated, thus developing one of the forms of pulmonary tuberculosis called phthisis. On the other hand, small tubercles in the lung may, with or without extensive necrosis, become surrounded by, or converted into, masses of dense fibrous tissue. These fibroid masses, which are often called "healed tubercles," may contain necrotic material, are often mottled black from anthracotic pigments, or may be calcified at the center."

This is again stated by Ziegler: "It is very doubtful whether complete recovery of the affected tissue by re-absorption of the exudate is in any case possible, and indeed, it can only occur in the very smallest patches whose vessels are not yet obliterated. In larger patches, healing can only take place when the inflammatory process issues in fibrous hyperplasia and induration."

However, in 1858, Virchow stated: "The cheesy transformation is the regular termination of the tubercle, but, on one hand, it is not the necessary one, inasmuch as there are rare cases in which tubercles, in consequence of their undergoing a complete fatty metamorphosis, become capable of re-absorption; on the other hand, the same cheesy metamorphosis

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befalls other kinds of cellular new formation, for pus may become cheesy, and likewise, cancer and sarcoma."

In 1922, Gardner proves: "Caseous tubercle can heal by resolution and finally disappear completely." The basis of this report is the work of Dunham and Skavlem, who state in their conclusions that "certain *x*-ray densities suggest definite cellular pathology." We accept this research as correct and go a step further and claim that certain *x*-ray densities not merely suggest, but may be definitely read in the language of cellular pathology.

At some future time, a more complete report of these autopsies will be made. This report is based upon gross pathology. Sixty-four autopsies were held during this fiscal year. Nine of these were not *x*-rayed before nor after death; 34 cases were *x*-rayed before death, and densities of caseous bronchopneumonia were read from the plates. These were found by the pathologist in the lobes as described. In the 35th case, caseous bronchopneumonia was found in limited areas by the pathologist, but three months before death, the roentgenologist did not observe this.

Fifteen cases had no chest plates made during life, but comparison was made between the roentgenologist and the pathologist by means of lung plates made after death. Fourteen of these tallied. One did not agree: The pathologist's diagnosis was bronchopneumonia due to tuberculosis; the *x*-ray diagnosed bronchopneumonia probably not due to tuberculosis. In 5 cases, death was from causes other than pulmonary tuberculosis. The pathologist and roentgenologist agreed completely in these 5, but no caseous bronchopneumonia was found.

We believe that a study of these autopsies justifies the conclusion that caseous bronchopneumonia can be detected from the *x*-ray plate. This justifies the statement that certain *x*-ray densities may definitely be read in the language of cellular pathology.

The proof of this claim rests, then, on this comparison of *x*-ray plates and the autopsy findings in 55 cases, and on a study of 59 cases still living, that have shown the same densities in *x*-ray plates which have disappeared coincident with a clinical improvement.

It is interesting to look back over our work and watch the evolution of this idea. In May, 1920, we find this note in the history: "The caseous bronchopneumonia is not so dense as shown by the plates six weeks ago." Similar readings occur with increasing frequency until, in February, 1921, the following was noted: "These plates show to what extent caseous bronchopneumonia can clear up." From May, 1920, until July, 1921, such observations were recorded some 20 times. We have limited this study to cases observed from July, 1921, to July, 1922. Some of the cases had been observed many years previously, but the routine of the hospital brought every one of these cases to our attention during these twelve months. None were dragged in, and many interesting examples were left out because they did not come to us by routine.

In all, 489 cases were examined; *x*-ray densities diagnosed as exudate decreased or disappeared in 67 or 13.7 per cent. Eight of these were not proven tuberculous, leaving a little more than 12 per cent. Of these 8, 4 had 4++++ Wassermann; 2 were finally proven interlobar empyema, and the remaining 2 were very atypical, and an etiological diagnosis of the supposed exudate was not made.

Fifty-one cases had positive sputum sometime during their residence. Thus, we have diagnosed 8 as tuberculous without positive sputum. Three of these are positive from the history, symptoms, physical findings and *x*-ray examinations, but tubercle bacilli have not been found in the sputum. Three young children had no sputum. The physical signs are suggestive, but history, symptoms, *x*-ray plates and Von Pirquet are very positive. One young girl had no sputum, but had typical fans of differing densities, characteristic of tuberculosis, which have disappeared in one part of the lung only to appear in another. One adult had no sputum, but otherwise, the diagnosis is beyond question. We unhesitatingly diagnose these 59 cases as pulmonary tuberculosis.

As was expected, sex seems to have no special influence: 42 cases or 71 per cent

being males and 17 cases or 29 per cent being females, the proportion in 489 being 69 per cent and 31 per cent.

Regarding ages, of the 489 cases examined, 278 or about 57 per cent were over thirty. Of the 59 cases showing the absorption of caseous bronchopneumonia, 38 or about 64 per cent were over thirty. This may indicate that this change is increasingly frequent with advancing age.

We were interested, though not surprised, at the findings regarding race. In the period during which these observations were made, plates were made of 489 cases. Of these, 384 or 78.5 per cent were white, and 105 or 21.5 per cent were colored, but of the 59 cases in which absorption was noted, only 2 or less than 2 per cent were negroes. One of these is a negro boy, admitted in July, 1915, aged eight. The diagnosis on admission was incipient pulmonary tuberculosis with a slight lesion in the upper left lobe. He has been re-admitted 4 times since, and through a series of 6 *x*-ray examinations, we have watched this lesion develop. A cavity has formed and caseous bronchopneumonia has appeared. In the last set of plates made on July, 1922, the cavity is very clearly defined by a thick wall while the exudate is being absorbed. The other negro shows only slight absorption.

In classifying these 59 cases as to degree of absorption, we have noted:

7 in which the change was slight
24 in which the change was moderate
18 in which the change was marked

The remaining 10 are left in a class by themselves, because, while the caseous bronchopneumonia has been absorbed at some time during the period of observation, seeming to indicate improvement, in other parts of the lungs retrogressive changes, most frequently the increase in size of a cavity, have occurred. Three of this class died during the year.

Case I. White male, aged forty-seven. When first admitted, in July, 1913, had a history of illness dating six months previously, moderate cough, little sputum (negative) slight hemoptysis, temperature in July, 98 to 104.6° F., becoming less on usual rest treatment. Was given protoiodide of mercury because of luetic history.

Roentgen Examination. Plates No. 429, made October 6, 1913, show marked involvement of the right side with probable cavity. Left did not show much pathology. Pneumothorax treatment was begun and Plates No. 438 made October 14, 1913, 481, 505, 515, 524, February 8, 1914, illustrate phases of this collapse. He received in all about 15 treatments. When he was discharged, in May, 1914, at his own request, he had gained 13 lbs. and his temperature had been below 100° F. for three months.

Re-admitted September 26, 1914. Had continued to improve. "Breath sounds have returned to the right side and were heard all over the chest." No plates at this time. Was in hospital until January 9, 1915. French leave.

Re-admitted August 6, 1915, with temperature of from 97 to 103.4° F. Had lost 17 lbs. Again improved and again took French leave, January 11, 1916.

Re-admitted November 15, 1916, in fair condition, gaining in weight. Plates 1092 show oldest lesion in the upper right; dislocation of the thoracic viscera upward. Lesion in left vertebral trunks. French leave, February 1, 1917.

Re-admitted August 26, 1919. Wassermann negative. Sputum negative. Signs of cavity in the upper right. Again improved and again took French leave two months later.

Remained out until July 26, 1920. On readmission, sputum was positive and Wassermann negative. Physical signs on both sides, more marked on right with cavity. Temperature 96 to 100° F. Weight 115 lbs.

Roentgen Examination. Plates No. 1860, made October 24, 1920, show benefit of pneumothorax which has definitely arrested the lesion in the upper right, allowing greatly increased fibrous tissue to develop around the upper right, so that when this lobe broke down, with cavity formation, the lesion was well walled off and drained well. Definite lesion seen in the upper left and definite mottling suggesting caseous bronchopneumonia from the third rib to the fifth interspace and, to a less extent, in the lower right. Again improved and again took French leave December 1, 1920.

Three times has this story been repeated, his last admission being on July 26, 1922. Wassermann is now positive and the sputum contains tubercle bacilli.

Roentgen Examination. Plates No. 3139 show the large cavity in the upper right with heavy capsule and thickened pleura drawing the trachea over. With this, a definite decrease in caseous bronchopneumonia is noted in the lower and middle lobes. There may be beginning caseous bronchopneumonia in the lower left.

Case II. White male, aged thirty. Admitted June 26, 1921. History of pneumonia in infancy and again five years ago. "Subject to bronchitis and bad colds" since. Twenty to 30 lbs. underweight. Severe cough with expectoration, worse at night. Positive sputum; negative Wassermann. Temperature very irregular —in the evening 98.8 to 101.6° F. within two weeks; pulse also irregular. Physical signs indicated scattered areas of involvement. A diagnosis, confirmed by roentgen examination, Plates No. 1778, made August 18, 1920, showed a slight lesion in right vertebral trunks; confluent caseous bronchopneumonia, first and second interspace trunks; slight involvement apex of lower right. Heavy tuberculous fans in the anterior branches of the vertebral trunks, left side; faint cloud due to tuberculous pneumonia, but not *caseous*, in the posterior branches of the first interspace trunks; area of caseous bronchopneumonia in the anterior branches of the second interspace trunks.

Patient improved; temperature and pulse more steady; gained 24 lbs. in weight in the two months before he took French leave. Was out only eleven days.

Roentgen Examination. Plates No. 1902, made December 12, 1920, four months after the first set, show the absorption in the upper right with the development of a cavity. A similar change has occurred in the left lung. Cavity has developed behind the second interspace. The fans in the vertebral and first interspace trunks show decreased density, and the fan in the second interspace trunks is more blotchy, suggesting caseous bronchopneumonia rather than caseous pneumonia. Physical signs are much more marked, but no evidence of cavity is found. In March, the patient again took French leave, remaining out three months.

His third period of residence lasted from June, 1921, until February, 1922, when he went to New Mexico. Plates No. 2736 show great change in the right lung. There is now an area of emphysema in the vertebral trunks above the clavicle. The first interspace trunks show evidence of increased scar tissue which may be the result of contracted cavity. Linear markings of the second interspace trunks are now obscured by a faint cloud, but no caseous bronchopneumonia is noted. In the left lung, the vertebral trunks are heavy, as are the posterior branches of the first interspace trunks. An area within the second interspace trunks now shows a cavity. In the lower left, near the angle of the scapula, there is still increased density, but not as heavy as before.

Case III. White male, aged twenty-eight. Admitted February 26, 1921. Typical history of pulmonary tuberculosis. Sputum positive.

Roentgen Examination. Plates No. 2064, made March 3, 1921, show pulmonary tuberculosis chronic, fibroid, active, far advanced; adult, apical type. Unusual abnormal density seen behind the third rib, upper right, which appears to be a cavity surrounded by caseation. Caseous bronchopneumonia in the right base. More recent fans in the upper left. Prognosis very grave; will probably not live over a year.

Roentgen Examination. Plates No. 2134, made April 8, 1921, show that infiltration throughout the right, especially in the lower lobe, is much less; not so marked in the left. Cavity not now in evidence, but great masses of increased density are seen in the upper and lower lobes. The lesions lie much higher. This may be due to the extent of inspiration, or to a dislocation of the thoracic viscera due to absorption of exudate and contracted tissue. Temporarily, the prognosis is better.

Roentgen Examination. Plates No. 2218, made May 21, 1921, show most unusual absorption of exudate throughout both lower lobes, especially the right. The upper right now seems to contain two

large cavities which have been compressed by contractile tissue and thickened pleura. Thickened pleura between the upper and middle right lobes and drawn up so that it lies behind the third rib. The fan in the upper left has been absorbed. Two areas of lesser density, which might be beginning cavitation, are seen behind the second rib, upper left.

Roentgen Examination. Plates No. 2540, made October 22, 1921, show that the thickened pleura now lies behind the second interspace. The cavities are so contracted that they would probably be overlooked. Very little further absorption.

Roentgen Examination. Plates No. 2786, made March 9, 1922, show trachea to the right. Thickened pleura between the upper and middle right lobes is still made out behind the second interspace. Cavities have disappeared, and in the upper right, only a massive fan is noted in the first interspace, and some mottling at the apex. Great absorption of exudate is noted in the upper right. Abnormal densities in the middle right behind the third rib, which suggest caseous bronchopneumonia. The massive caseous bronchopneumonia in the lower right has almost entirely disappeared. Delicate fans are made out in the vertebral and first interspace trunks only, and the exudate in the second interspace trunks is almost absorbed.

Clinically, the case has shown marked improvement. Was admitted with temperature from 97 to 102 and 103° F.; weighed 137 lbs.; sputum positive. He now seldom has a temperature of over 99° F. and weighs 152 lbs. Sputum negative last month on several examinations. Rales, formerly heard throughout, except at the left base, are now very few, and confined to the upper lobe.

Case IV. White male, aged twenty-three, (Filipino). Admitted October 8, 1920. History of "colds" for several years. Slight hemorrhages for the past year. Very little cough. Wassermann negative. Sputum negative on admission, positive once, about a year later, after a series of hemorrhages.

Roentgen Examination. Plates No. 1854, made October 21, 1920, show lesions involving the entire right lung. Old fibrous fans in the right apex and in the first interspace trunks of the upper right. Caseous bronchopneumonia noted in the second interspace trunks, upper right. The middle and lower right lobes are studded with small confluent areas of caseous bronchopneumonia. Some in the lower left, but not so extensive. Bronchiectatic cavity is suggested in the first interspace trunks, upper right.

Roentgen Examination. Plates No. 2020, made February 9, 1921, show that the lesions in the upper right are less fan-like. The mottling is much finer in the middle and lower right lobes. The cavity is still present. Six months later, during three days (August 3rd to 6th) lost about 50 oz. of blood. Temperature for about ten days, 101 to 100° F.

Roentgen Examination. Plates No. 2633, made December 3, 1921, show that lesions on the left side have entirely disappeared. The right side shows great absorption. Definite fan seen behind the first rib and clavicle; probably the first interspace trunks contain two bronchiectatic cavities. Fan in the second interspace trunks, coming to the surface under the fifth rib. In the middle right an unusual area of increased density involves the linear markings of the upper branches of the trunks coming to the surface in the third interspace, anterior axillary line. The rest of the lobe is emphysematous. Further absorption is noted in the plates of February, 1922. Not reproduced.

Case V. White female, aged twenty-two. First plates were made elsewhere in December, 1919, and read at the Cincinnati Tuberculosis Sanatorium. No. 1763B. Plates are thin, and it is impossible to exclude a tuberculous lesion in the left apex. In the second interspace trunks, upper left, there is a large mass of exudate containing a cavity.

Roentgen Examination. Plates No. 1763A, made in August, 1920, eight months later. These plates show definite lesion in the upper left as suggested above. Definite diagnosis not made from the plates, because the cavity is unusually large for the amount of fibrosis in the apex. Sputum, a few days later, contained tubercle bacilli, only positive during period

of observation. Patient was admitted August 10, 1920, and three weeks later was transferred to Ohio State Sanatorium, where she remained under treatment for thirteen months.

Roentgen Examination. Plates No. 1925, made December, 1920, about one year after the first set of plates, show definite lesion in the left apex. Cavity in the second interspace trunks has been replaced by an irregular mass of increased density immediately behind the second interspace. This contains several small areas of decreased density, which might be contracted cavities.

Roentgen Examination. Plates No. 2361, made July, 1921, show a density in the second interspace trunks, upper left, indicating more fibrosis; and the lesions in the vertebral and first interspace trunks seem more active. Increased activity in the right vertebral trunks; decrease in the second interspace trunks.

Roentgen Examination. Plates No. 2599, made November, 1922. The exudate in the second interspace trunks, upper left, has been absorbed to a large extent. The cavity is now more definite and suggests greater fibrosis. The fans in the right apex and second interspace trunks, upper right, are much more definite. Patient continued to work with no symptoms of tuberculosis until early in February, 1922, when she suddenly developed pain in the right side with dyspnea and coughing spells, but no sputum. Temperature 103.2° F.

Roentgen Examination. Plates No. 2767, made February 22, 1922, show that the most striking change is the hazy density over the right base. There is evidence of thickened pleura over the entire right side and between the upper and middle right lobes. The diaphragm is drawn up and attached to the lateral wall. The fan previously noted in the right apex is heavier. The fan in the second interspace trunks is obscured by the haziness just described. It is impossible to determine whether the density is wholly due to lesions within the pleura, or whether the pleuritis is the result of inflammation within the lung. The lesion in the left lung has cleared up remarkably. A definite fan still remains in the vertebral and in the first interspace trunks, but the cavity has greatly contracted, so that it now seems to be bronchiectatic. The heart is not drawn to the right. Needle was introduced into the chest, but no fluid was obtained. The temperature came down very quickly and in about a month, became normal. The patient was discharged April 1st, and returned to work.

Just before discharge, Plates No. 2847 were made. The fans described on the right side are now seen only with difficulty. There is still some pleural thickening between the upper and middle right lobes. The diaphragm is attached to the anterior, lateral and posterior walls. The lower and middle right lobes are compressed by thickened pleura. The heart is now beginning to be drawn to the right. Definite thickening of the linear markings of the middle and lower right lobes.

Primarily, the lesion at the right base is a pleuritis. The extent of the inflammation within the lung is not determined, and the question arises: What form of pleurisy may occur without fluid which would cause such marked change? It is now impossible to say that there is a definite fan in the left apex. The lesion in the second interspace trunks shows only an old contracted fan reaching the lateral wall, posterior axillary line. Enlarged bronchi are noted, but there is no evidence of a bronchiectatic cavity.

Roentgen Examination. Plates No. 3147, made July 29, 1922, the last set of plates made, show that the remarkable change previously noted continues to be seen on the right side. The pleura is thickened from apex to base. The right diaphragm is lower than on the previous plates. The pleura is definitely thickened between the upper and middle right lobes. Slight increased density at the right base may be due to previous compression of the lung, or to some inflammation within the lung. This density is not characteristic of tuberculosis. No apical changes are noted. On the left side, a delicate fan is noted in the apex, and another, involving the posterior branches of the first interspace trunks. These are quite characteristic of tuberculosis. The large mass of increased density, so frequently noted in the second

interspace trunks, anterior branches, which previously contained a cavity, now has the appearance of a contracted fan with heavy striations of connective tissue.

Case VI. White female, aged twenty-two when first admitted, in April, 1918. Nothing unusual regarding history, which extended over a period of about eight months. Beside the usual history of cough and expectoration with loss of weight and strength, she had hemorrhages of 2 to 4 oz. in the four months preceding admission. About three months after admission, she had a series of hemorrhages, amounting in all to about 39 oz., and extending over a period of less than ten days. Physical examination and history indicate the same improvement as that shown by the *x*-ray plates. About the time the first plates were made, rales were heard throughout the left lung, and signs of cavity found. These were not as typical as would be expected from the *x*-ray plates. Sputum positive, has recently been negative. On admission, patient weighed 99 lbs.; present weight, 123 lbs.

Roentgen Examination. Plates No. 1481, made in May, 1919, show in the right side a slight clouding in the linear markings of the vertebral and first interspace trunks. The linear markings in the second interspace trunks, behind the second and third interspaces and the midlobe trunks behind the fourth and fifth interspaces are studded, suggesting bronchopneumonia. A definite fan of increased density occupies the linear markings of the vertebral trunks, upper left. A circular area of increased density, lying with its rim close to the chest wall just inside the third rib, is noted on the left side. This appears to be a cavity.

Roentgen Examination. Plates No. 1672, made a year later, show most extensive lesions still in the upper left. Definite lesions are noted in the left apex and in the second interspace trunks posteriorly just above the fifth rib. In the upper left posteriorly, there is an area of decreased density, surrounded by increased density, which might be the result of a cavity. Slight apical lesions are noted in the upper right.

Roentgen Examination. Plates No. 3138, the third set, were made in July, 1922. No evidence of abnormal density is now seen on the right side except along the vertebral and first interspace trunks. The old fans are becoming more and more contracted in both apices and in the second interspace trunks, upper left.

CONCLUSION

We regret that we have not verified Gardner's work by pathological research upon human lungs, but we feel that his statement, "Caseous tubercle can heal by resolution and finally disappear completely," is correct; and further, that such frequently occurs in man. Absorption of tuberculous exudate may change a desperate to a more favorable prognosis.

DEEP X-RAY THERAPY*

BY REGINALD MORTON, M.D.

LONDON, ENGLAND

DEEP *x*-ray therapy is primarily a question of *x*-ray dosage, since it is definitely proved that under certain well-defined conditions an abnormal cell will die after an exposure to the *x*-rays that is insufficient to destroy normal cells. Purely superficial conditions are easiest to deal with, but central lesions take longer, though not difficult to treat. Subcutaneous lesions are the most difficult of all.

1. Primary Radiation. Almost any type of radiation from a tube of not less than medium hardness will give a good result if correctly used, but if the lesion has any appreciable thickness, or is placed at an appreciable distance beneath normal skin, the whole problem is completely changed.

Whatever type of radiation is used, there is a limit of skin tolerance that must not be exceeded. For any given dose at any given depth this limit is reached sooner when the tube is softer (longer wave-length radiation is easily absorbed). To increase the depth-dose we require "hard" (short wave-length) tubes, with a suitable filter to absorb all the longer wave-lengths, and a resultant beam of radiation that for all practical purposes is homogeneous. If the beam is not homogeneous, not only is the discrepancy between the deep and superficial doses undesirably large, but it is almost impossible to estimate the dose at any given depth with even approximate accuracy. Without an exact calculation, the dosage cannot be other than haphazard—pure guess-work.

Again, if we alter the wave-length with which we are working, not only is it necessary to alter the absorption factor of the filter, so as to get homogeneous rays, but we also alter the percentages of the skin dose delivered at any given depth. Consequently, if we desire to administer doses of *x*-rays to any lesion with sufficient accuracy, we must use homogeneous rays, all the factors concerning which have been fully worked out, and we must stick to that particular type of radiation.

So much for the primary radiation from the *x*-ray tube, which is quite different from that which gives the best results in diagnosis; and probably few things have done more to delay the advance of *x*-ray therapeutics than the demand for equipment adaptable for both purposes. The conditions are quite different and cannot be met in one apparatus without detriment to one or the other, or to both!

2. Secondary Radiation, Including Scattered Primary Rays. This radiation set up by the primary ray on whatever it falls, is a nuisance in diagnosis, but an important ally in therapeutics. It is difficult to measure with any accuracy, but we know that at any given depth it increases directly (*a*) with hardness of the tube, and (*b*) with the size of the field irradiated, within limits.

The increase accompanying the more penetrating type of radiation may be due to the larger percentage arriving at any given depth, or it may be that the shorter wave-lengths more readily excite secondary radiation; possibly a combination of both. These matters may be left to the physicist, but it has been found that while the secondary radiation increases rather rapidly as we increase the hardness of the tube up to a point where a voltage of about 200,000 is necessary to keep the tube in action, this increase no longer keeps the same relation to the voltage as this point is passed, and we add much to the problem of heat-dissipation without sufficient gain in other ways. I refer particularly to "gas" tubes. It is possible that with special Coolidge tubes and voltages of 500,000 or more, conditions will be sensibly improved.

The increased irradiation of any point that follows an enlargement of the irradiated field surrounding it, will continue so long as some part of the secondary radiation at the periphery can overcome the loss by dispersion and absorption on its way to the center. No advantage can follow an enlargement of the field of irradiation beyond this point.

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

It is here that the splendid charts by Dessauer come to our aid. With them we can so modify our technique as to get even irradiation of any lesion of reasonable size at any depth usually found in medical work.

These charts are an inestimable boon to the radiotherapist. The broad principle taught by them is the importance of the secondary radiation and how by proper adjustment of the size of the field irradiated we gain an almost complete control over our dosage.

With this brief sketch of the physical conditions underlying *x*-ray therapy, let us now consider the biological aspects of the problem. Here I would like to pay a most generous tribute to the magnificent work done at Erlangen by Professors Seitz and Wintz, and their able staff of assistants. They have evolved what may justly be described as the first complete system of *x*-ray therapy having a sound physical and biological basis. It is not the last word on this subject, nor has it ever been claimed to be the long-sought "cure for cancer," by anyone competent to speak with authority. Nevertheless, it is the first real step towards that end, and in all probability will eventually lead to the discovery of some technique that may be regarded as a cure, within certain limits. Indeed, there are signs even now that we are not so very far away from that.

While it has been well known for a long time that living tissues undergo certain changes after exposure to the *x*-rays and that some kinds are more sensitive than others, it is only in recent years that our knowledge has attained some degree of precision. The changes seem to be primarily in the nucleus, in the matter of chromatin. The nucleus is the most highly organized part of a cell, and chromatin is radio-sensitive. The nucleus disintegrates, the cell vacuolates, and finally breaks down and is carried away by the lymphatics. But the changes are brought about more readily in abnormal cells: the more embryonic the type the more susceptible is it to radiation. The most susceptible period in the life-history of any cell is when it is undergoing division.

At present we require some unit of dosage, and the one that seems to be most firmly established is the Unit Skin Dose of Seitz and Wintz. Working under their prescribed conditions, which are easily reproducible with the equipment that they have evolved, this dose gives rise, after about five days, to a slight hyperemia which gradually subsides, leaving the skin undamaged though pigmented or "tanned." Taking this U.S.D. as 100 per cent, the limit of tolerance is as follows:

Muscle 180 per cent.
Intestine 135 per cent.
Ovary 35 per cent; temporary, 28 per cent.
Tuberculosis 50 per cent.
Sarcoma 60 to 70 per cent.
Carcinoma 90 to 120 per cent. Forty per cent stimulates; 60 to 90 per cent paralyzes.

Non-malignant growths, such as adenoma of the prostate, require a full U.S.D. because the cells are nearly normal and less embryonic.

Of malignant growths, the carcinomatous type is the most resistant, and the hard, slowly growing, scirrhous type is more resistant than the soft encephaloid. A 90 per cent dose may do for the latter; the former requires 110 or even 120 per cent.

While sarcomatous growths respond more easily, this advantage is more than neutralized by the proneness of the type to early dissemination. It is probable that this process has already begun in the great majority of cases before they come under treatment.

With regard to cases of localized, non-septic tuberculous lesions, such as cervical glands, bones and joints in young subjects, I believe there is a large field of usefulness here for intensive *x*-ray treatment, and I understand some very excellent results have been obtained. I have not given any myself.

Measurement is carried out by means of the iontoquantimeter, or it can be done with Kienboeck's Strips. Dosage is controlled by time alone, once the activity of the tube has been ascertained. Tubes should be recalibrated after each twenty hours of use.

Coming to more practical details, let us first consider those conditions that make for success:

1. General health practically unimpaired; normal red count. Never irradiate if reds are below 4 millions; or if there is marked anemia or cachexia. A full irradiation may cause a fall of 20 per cent with an average of about 10 per cent.

We must keep in mind the fact that there is neither miracle nor mystery in this procedure. The most that irradiation can do is to turn the scale in favor of the patient, or, to put it another way, to help Nature to help herself. The cure has to be done by the patient's own vital processes, and these cannot work efficiently in the absence of a rich blood supply.

2. The lesion must be localized to a reasonably small area, with no wide local extensions. No treatment can be of any avail in saving the life of the patient, once general dissemination has begun.

3. Every part of the growth must be accurately, evenly, and thoroughly irradiated; the *x*-ray technique must be perfect.

4. The general health must be carefully looked after during the subsequent weeks.

If all these conditions are present in any given case, it may be laid down, at least as a broad principle, that the abnormal growth will disappear. This is essentially as stated by Wintz, and though I rarely get cases under these favorable conditions, my experience enables me to accept it.

There is an important point that must not be overlooked. A large number of the cases that come to us are recurrences after surgical operation. These are not so favorable for us. Successful irradiation depends on a normal vital reaction, increased blood supply, leucocytosis, phagocytosis, etc., with free blood and lymph circulations. This is impossible in an area that has been the site of a more or less extensive surgical procedure. Circulations are but partly restored, and vital reactions are inefficient.

TECHNIQUE

In practical work we are bound by certain limitations. No skin area or other normal structure, as far as possible, is to receive more than the U.S.D. Not that a moderate overdose would, in itself, constitute a grave injury; the sharp local reaction following such is far removed from the *x*-ray burn of former days, when filters were inadequate (if we used any at all) to stop all the softer rays.

Overdoses, and also normal doses if repeated three or four times, bring about an obstinate local edema that is as undesirable as it is unique. These hard rays seem to have a special action on the local lymphatic circulation; it is particularly noticeable when treating lesions of the neck and maxillary regions. I have frequently seen a well-marked local edema come on during a first irradiation. It is not painful, and usually subsides after some hours, but for the time the outline of the face is quite altered. Occasionally, it is so slight that it may escape notice. If noticeable on a first irradiation it will be more noticeable on subsequent ones—progressively. The edema of over-irradiated skin gives the patient a feeling of "tightness;" the skin is not painful or seriously discolored, but is smooth, hairless, and of a firm boggy texture that pits readily on pressure, and can be pushed up into ridges which take some time to disappear.

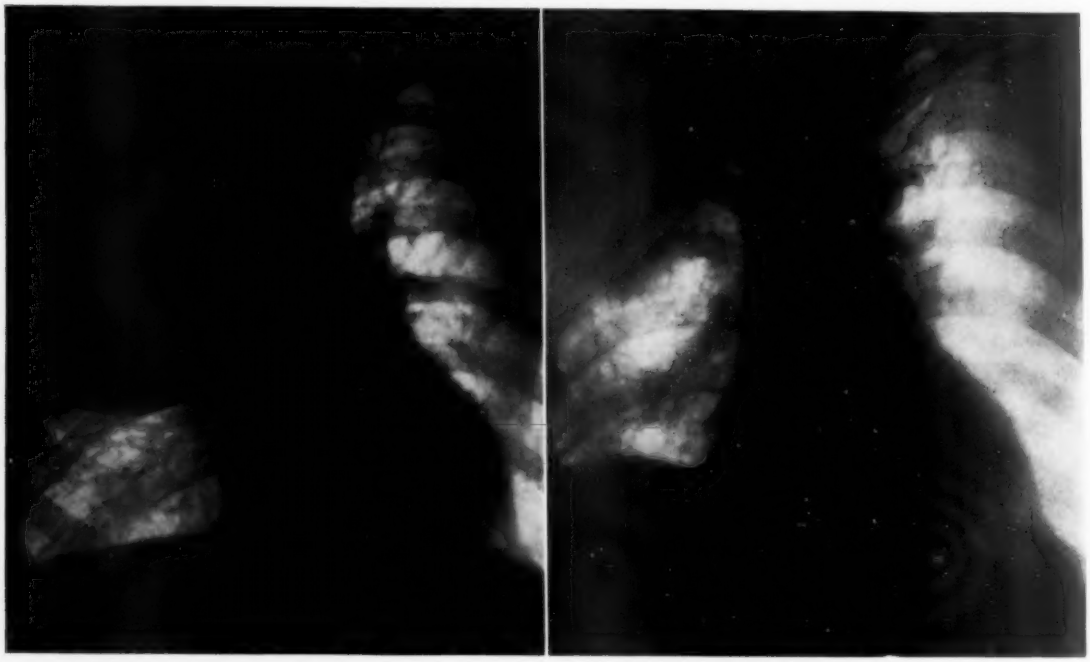
There is no doubt that the local lymphatic circulation has been profoundly, and probably permanently, altered, and I feel sure it is a condition we should try to avoid, since we depend so much on efficient local circulation for our results. Overdosing is inadmissible at all times and in all places.

The next difficulty is the loss of radiation, between the surface and the lesion beneath, by (*a*) dispersion, and (*b*) absorption. These are known, are constant and easily ascertainable, and need not detain us for the present. I would, though, remind you of the percentages in a typical case at the different levels below the skin, taking the dose on this as 100 per cent. They are at centimeter intervals—80, 65, 55, 46, 39, 34, 30, 26, 23, 20 (these approximate whole numbers, fractions being ignored). The point to be remembered is that as we get further down, the radiation tends to become more uniform. So far as experiments have gone up to the present, the depth percentages are not relatively increased by the use of

higher voltages and harder tubes than those normally used at Erlangen. Recent modifications have made it possible to reduce the time of exposure by approximately 30 per cent, but the depth percentages remain sensibly unaltered. Loss by dispersion can never be altered, and the factors of absorption and secondary radiation are not sensibly affected by moderate increase of voltage. Possibly an equipment designed to work successfully at 500,000 volts may so reduce exposures and increase depth percentages that we can treat two patients in the time we now take to treat one.

when we are dealing with living tissues? It would be very nice if we could snap-shot our cases in the way we take our holiday photographs, but there is a difference, and I feel that within limits a certain length of time is advisable and necessary. Living cells are far removed from photographic films; there is all the difference between *vitro* and *vivo*.

As I stated in the beginning of this paper, superficial conditions are easy to deal with. If the skin only is involved we can obtain a very even irradiation by a long focal-skin distance, increasing the



January 19, 1922. August 11, 1922.

This would be a decided practical advantage, and it is not improbable that the blood would suffer less by virtue of the shorter time. For the present I think it better to continue on the lines laid down at Erlangen, if only for the high degree of accuracy in dosage it gives us. It is being steadily improved in details, and even now gives some splendid results when accurately carried out in suitable cases and under favorable conditions.

There is another point I would like to raise. Speed is the great desideratum in most of our services; are we quite sure of the wisdom of pushing this to the limit

time as the square of the distance. The slight loss by dispersion and absorption is partly made up by the secondary radiation from the tissues beneath; up to a point the same applies to lesions less than about 2½ cm. from the surface, but even accurate dosage is difficult and the results are inferior.

Central lesions are probably the easiest to treat with accuracy. Having ascertained our depths, and knowing the percentages from each port of entry, we attack the lesion from as many points as are necessary to build up the desired dose; by using one or two extra ports of entry we can propor-

tionately reduce the time for each, giving less than the full skin dose. No skin reaction follows, and the same areas may be used again without risk of permanent injury, such as the edema to which I have referred. So long as we know the activity of the tube with which we are working, the site and extent of the lesion, and have an accurate knowledge of topographical anatomy, the treatment of central lesions is a perfectly straightforward matter.

As I have already stated, the difficult cases are those semi-superficial ones where we are limited practically to one port of entry, and particularly when the lesion is situated in those parts of the body having an irregular contour, such as the jaws, neck, female breast, vulva, and anus. In addition to the difficulties due to locality, lesions involving or communicating with the various apertures have the further complication of sepsis, and a very formidable one it is.

For a long time, the general method of treating these lesions was that of "distant radiation," where the anticathode was placed at any distance up to 100 cm. from the surface, the time of exposure extending from six to ten or twelve hours.

Placing the tube far away helps us in two ways. It not only lessens the influence of contour irregularities, but also makes the depth percentages more favorable and more uniform. This is all to the good, and while some excellent results have been obtained, there is much room for improvement.

We have seen that it is more easy accurately to irradiate central lesions; also that the deeper down we go, the more uniform is the irradiation. If we could temporarily convert our superficial or semi-superficial lesion into a central one, from a radiological point of view, many of our difficulties would vanish. Fortunately, this is not beyond us. Supposing the lesion is 1 cm. below the surface, and that we place between the applicator and the surface a block 10 cm. thick of some material having the same absorption and secondary radiation value as normal tissues. Several substances answer to these requirements; water is one, though perhaps not the most convenient to use; paraffin wax, beeswax, and dough made from ordinary flour are all suitable. Casman of Antwerp makes first a sort of shell mold of the part with softened paraffin wax. This we may call the *negative*. From this an assistant makes a positive in plaster of Paris. From the latter he makes the final negative, casting it in two halves in a proper molding box. When the patient comes for treatment the part is enclosed in this mold and treated as for a central lesion. In this way he gets a wonderfully even irradiation of these superficial lesions and more satisfactory results.

Many cases can be treated on this principle without the trouble of making the mold. Returning to the lesion I have just instanced, with 10 cm. of wax between the skin and the applicator, we know the percentage we get at this depth, say 20 per cent. Therefore, we can expose five times as long before we get the U. S. D. at the skin surface, and we will find that we have got over 90 per cent at 1 cm. below the surface instead of just under 80 per cent when the applicator was in contact with the skin. This is nearly as much as we want, and an application from the opposite side or other convenient angle soon completes the dose. In practice, we use as many ports of entry as convenient and equalize the portions of the dose among them.

A set of wax blocks of various sizes and thickness are invaluable and will obviate the necessity for elaborate molds. For very irregular surfaces the inequalities can be first leveled up with a dough made of flour and starch paste. The latter gives it a firmness, pliability, and freedom from stickiness that is very desirable. Wax blocks are then piled up to such depth as is desired.

Here is a field for exercise of some ingenuity; we want some ever-ready, convenient means of enclosing these lesions in a medium that complies with our requirements. What about water-containers with sides or ends made of thin rubber so as to be easily adaptable to surface irregularities? Again, why not some material like "Plasticine" that could be molded at will?

Plasticine in its present form is not suitable, owing to its very high absorption,

due to the presence of materials of high atomic weight. Perhaps the makers of this material could provide a special mixture answering our requirements; one that would be easy to mold, clean to handle, and yet sufficiently firm to retain its shape at normal body temperature. This subject is worthy of attention, and I hope something will be done without long delay.

Before I close, there is a question I would like to ask. As is well known from past experience, repeated fractional doses of *x*-rays have an inhibitory influence on cancer cells, but if we increase either the individual doses or the frequency of their administration, so that the cumulative effect reaches a certain point, such cells are stimulated to active proliferation, and may bring about a visible increase of the tumor within twenty-four hours. Are there not certain circumstances where we might turn this property to good account? Some cancerous growths are very resistant to radiation—probably because they are made up of a more fixed type of cell. We know that cells are more vulnerable while undergoing division; why not give such a growth a stimulating dose first so as to bring on proliferation? Then, as soon as this is established, irradiate again right out to the full lethal dose. Naturally, the scheme is applicable to a limited number of cases, but I am rather attracted to it. Some may consider it too risky, but after all, what are the circumstances?

Is it not the case that the patient with malignant disease is fairly "up against it" for his very life? Is it not also the case that, with deplorably few exceptions, the patient with malignant disease dies of that disease? So long as we have knowledge and experience of what we are doing, are we not justified in taking these risks on behalf of our patient? I think this point is one worthy of discussion.

One more detail before I close. There is a tendency among medical men generally, from which radiologists themselves are not altogether free, to attach too great importance to the apparatus, and too little to the man in charge of it. We do not estimate the capabilities of a surgeon by the keenness of his cutting edges, or even by the extent of his surgical armamentarium. I have seen a lady walking about Edinburgh, with a scarcely perceptible limp, whose astragalus was excised, in an emergency, by a famous surgeon personally known to myself, with no other tools than his pocket-knife and a screw-driver! The operation was a brilliant success from every point of view.

What I want to emphasize is this, particularly as regards *x*-ray therapy. The roentgenologist who knows his subject, and the capabilities and limitations of his equipment, will always get a higher percentage of favorable results than his intellectually inferior colleague with the most elaborate apparatus available.

In conclusion, and by way of encouragement, I shall relate to you briefly the essential details of 2 or 3 cases I have treated. In the early part of this year a leading London surgeon asked me to see a lady with a cancer of the right breast; one of those diffuse, discolored, rather rapidly growing tumors, with enlargement of the axillary and infraclavicular glands. He considered it quite unfavorable for operation. The question was, could I so far improve the local conditions as to make surgical intervention feasible? Six weeks afterwards, glandular enlargements had almost completely vanished (only one irradiation) the tumor itself had disappeared, had lost all its malignant characteristics and the breast itself was almost normal, except for the deformity brought about by the shrinkage of the growth. The patient is now wonderfully well and the question of surgical operation has been shelved indefinitely.

In March, 1921, a man of forty-two, in a very weak and emaciated state, was admitted to St. Bartholomew's Hospital suffering from cancer of the esophagus; the obstruction was practically complete and a gastrostomy was done to obviate death from starvation. He had lost over 50 lbs. in the previous five months. A little over a year ago I gave him *x*-ray treatment at the West London Hospital. Within three weeks, food began to pass through the obstruction, and a day or two later, he used the gastrostomy opening for the last time. He has had two irradia-

tions since; he is now back to his normal weight, and when it comes to putting away a square meal, he can keep his end up with the best of them.

On St. Patrick's day of last year, I treated a gentleman who, a few weeks before, had been opened up for obscure abdominal symptoms. He was sixty-seven, with a cachectic appearance, though there had been only a moderate loss of weight. A typical carcinoma of the pancreas was found, the opening was closed, and nothing was done. He was rather upset by the treatment and was in a feeble condition for about three weeks afterwards. He began to take food more freely, and steadily to improve in every way. At the end of July he was going about as usual, traveling frequently between London and Paris without undue fatigue, and for the past twelve months he has not had a single unfavorable symptom.

In July, 1921, a gentleman was brought to me with what had been definitely diagnosed by a leading urologist as malignant prostate. He had arrived at the catheter stage, was slowly losing weight, and was just beginning to show signs of a commencing cachexia. He had only one irradiation. The catheter was put away five weeks later; he is now quite well and enjoying life.

In January, 1922, a gentleman was examined roentgenographically for dyspnea, among other symptoms, and was found to have a large growth in the upper right thorax, obliterating the upper lobe and bulging down over the middle lobe in front. The diagnosis was a sarcoma, possibly an encysted hydatid, and the case was regarded for all practical purposes as hopeless. In February, I was approached on the question of *x*-ray treatment, but owing to his weak, emaciated condition and the general seriousness of the case, I had no hesitation in declining to treat the case. I felt that the immediate effect would probably kill him.

He and his immediate relatives were quite alive to the seriousness of the situation as well as to the reasons I gave for advising against *x*-ray treatment. Two or three days later I was approached again with an urgent request to take the case in hand. The patient and his friends took the view that if I were correct, the worst that could happen would be an anticipation of what seemed the inevitable end, and if this did happen he would prefer it to lingering on; on the other hand, being a man with a clean medical history, who had always been in excellent health, he felt that he had a chance, and was ready to take all risks if I would consent to let him have "a run for his money." There was, of course, no alternative. He came on a stretcher by ambulance, and it was with no small sense of relief that I saw him back into the ambulance still alive, after the treatment was over, which I carried through thoroughly and completely. I saw him a few days before I left London. Considering the poverty-stricken condition of the Harley St. neighborhood, I chided him for lack of consideration in bringing such a picture of rude, rugged health into the district! For the first few days he felt rather more than usually prostrated, but this passed off. About ten days later the dyspnea began to subside and steady general improvement set in, continuing for several weeks. A second irradiation was given in May, as he seemed to have arrived at a stationary condition. Again rapid improvement set in and continued up to the time I last saw him—the day the second plate was taken, and a third irradiation given to shrink up further the mass that still remained. At present he looks in perfect health, and goes about briskly like any ordinary man of his age—forty-three. He still refrains from his favorite game, lawn-tennis, more out of respect for his medical advisers than from his own inclinations, but quite thinks he will have a game before the summer is gone.

AN UNUSUAL CASE OF DOUBLE SPONTANEOUS PNEUMOTHORAX*

BY CHAS. P. EMERSON, M.D., AND RAYMOND C. BEELER, M.D.

From The Robert W. Long Hospital, Indiana University School of Medicine

INDIANAPOLIS, INDIANA

FEMALE, No. 10314; unmarried; twenty-two years old; admitted to the Robert W. Long Hospital, September 21, 1920; discharged, January 8, 1921; readmitted, No. 11039, February 10, 1921; died, April 22, 1921.

Complaint. Asthma.

Family History. The patient's mother, aged forty-four, is living, but not well, for she has sick-headaches frequently and gets tired and "feels badly" as the result of ordinary household duties. Her father has undergone seventeen operations for a recurring growth in his nose, for which recently he has received radium treatment. The patient is the oldest of five children, two brothers and two sisters, all of whom are living and well, and none of whom have had asthma.

It is interesting that her father's grandmother, both of her mother's parents, two of her mother's seven brothers and one of her mother's three sisters all suffered from asthma.

Past History. When the patient was six months old she fell from her high-chair and "was unconscious for some time." She had "catarrhal fever" at the age of one year, whooping-cough with good recovery at four and measles at six. She never has had pneumonia. She has, since childhood, had frequent attacks of tonsillitis.

She had her first attack of asthma, which followed the exertion of walking to visit a neighbor, when she was two and a half years old. After that, the least exertion or a simple coryza would bring one on. Until she was eleven years old these attacks were much worse in the winter than in the summer, and were precipitated especially by exposure to cold air; but during the past ten years they have been worst during the months of June, July, August and September, during which months she suffers from one continuous attack of asthma which nothing seems to relieve, and on account of which she loses considerable weight. In the winter, the attacks are much less frequent and are more easily controlled. Until the last three years, the asthma has been accompanied by paroxysms of severe coughing which terminated with the expectoration of large quantities of sputum, sometimes "even a quart." Until the last few weeks, because of the dyspnea, she has, during an attack of asthma, never been able to lie on her right side. During the long, severe, summer attacks she has no appetite, suffers much from gas on the stomach and often, several hours after eating, vomits undigested food. She sometimes can relieve the asthma by inducing emesis. She has been so habitually constipated all her life that frequently the bowels have not moved for a week at a time, and yet, until the past two years, she has seldom used cathartics. The straining at stool has often made an asthmatic attack worse but has never precipitated one.

During an asthmatic attack, and also as the result of exercise during the asthma-free periods, she has complained of palpitation of the heart. Her lower extremities frequently have been edematous.

With the attacks of dyspnea the patient has always had "asthmatic" headaches, a severe throbbing in the temples, and also other headaches which glasses have relieved. She recently has had a continuous supraorbital pain. She has had frequent attacks of vertigo.

During the asthmatic attacks she has suffered from pollakiuria and polyuria.

The patient has never been able to do much work or to take exercise. She attended the common schools for seven years and high school for one semester.

Present Illness. Her asthma has been much worse this winter than last; nevertheless it is much better than it was last

* Read at the Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., February 22, 1922.

summer. She has recently not noticed any difference in her breathing capacity. She must lie in bed propped up, formerly leaning only on the left side, but during the past few weeks has been able to lean towards the right side also. She has gained about 18 pounds since last autumn, and now weighs 87 pounds.

Physical Examination. Her frame is slender, her musculature undeveloped and her nutritional condition poor. The skin has a yellowish pallor, but is not jaundiced, is inelastic and somewhat dry. The facial expression is intelligent and keen, but shows every evidence of intense suffering.

The eyes are normal; the pupils react to light and accommodation. The nasal septum is deflected to the left side, where it presses against the middle turbinate bone. The nasal mucosa has a grayish color and crusts which indicate an atrophic rhinitis. The tonsils, while not very large, are definitely infected.

The tongue is covered by a moist white coating. There is pyorrhea around several teeth, especially the two lower incisors.

There is no enlargement of the thyroid.

The thorax is definitely barrel-shaped, and therefore appears relatively large for the patient. It expands very little on inspiration. There is a marked kyphosis of the upper thoracic spine, winged scapulae and sternum and ensiform so prominent that the patient is definitely "pigeon-breasted."

FIG. 1. Sept. 30, 1920. Single film of the chest shows the contour to be barrel-shaped. The heart is small and hanging, the mediastinum slightly widened. There is exaggeration of the hila and of the linear markings throughout both lungs. On the right is a partial collapse of the lung, with a pneumothorax. This is especially marked in the upper third of chest.

FIG. 2. Sept. 30, 1920. Stereo plates show same condition as flat film. The pneumothorax is clearly outlined. There are some signs of adhesions because of inability of certain parts to collapse. The apices on both sides show considerable exaggeration of the linear markings. The diaphragms are somewhat fuzzy in outline, due to pleuritis. Costophrenic angles are slightly obliterated. The mediastinum and heart are displaced to the left. Both lungs show emphysema.

During the first of her stay in the ward she spent most of the time sitting up in bed leaning forward. Her dyspnea was distressing; all the accessory muscles of respiration were in use. The physical signs were those of a marked emphysematous chest during an attack of paroxysmal asthma; that is, the chest was definitely hyperresonant on percussion, the breath sounds loud, with tubular modification, and

accompanied by sonorous and whistling rales.

The point of maximum impulse was diffuse, located about 4 cm. from the midsternal line at the level of the fifth rib. There was some epigastric pulsation. The apex beat could not be distinctly palpated, but an impulse was felt 4½ cm. from the midsternal line in the fifth interspace. The right cardiac border could not be well defined. There was some retrosternal dulness. The heart sounds were distant, but clear, with the accentuation on the pulmonic second.

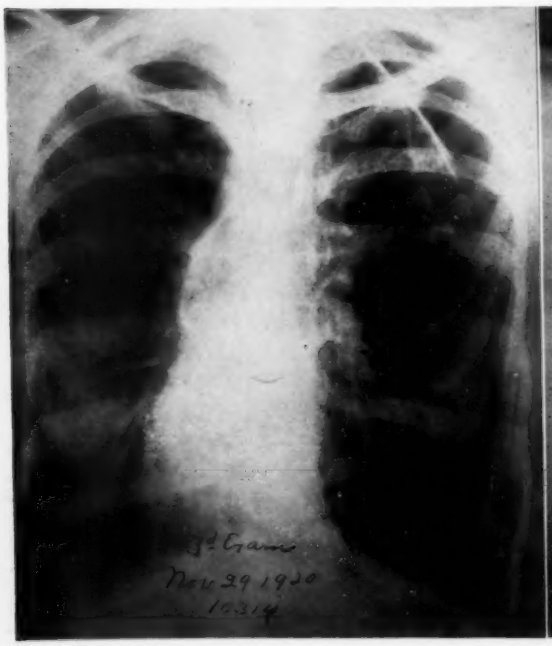


FIG. 3. Nov. 29, 1920. Stereoscopic plates show an increase in size of the right pneumothorax. The lung is collapsed from the first to the fifth rib.

FIG. 4. Feb. 14, 1921. Stereoscopic plates of the chest show almost complete collapse of right lung with exception of some adhesions in apex and posterior lower lobe.

The upper limit of deep hepatic dulness is about an inch above the costal border in the right mammary line. The lower border of the liver reached the level of the umbilicus in the midline.

There was no general glandular enlargement.

During her stay in the hospital this patient might for weeks be quite free from asthma. She then could walk around the ward with comfort, was quite free from cough and could lie with her head low, although she preferred the back of the bed always to be raised. She was, during these periods, a typical case of extreme pulmonary emphysema. During damp periods, and especially at night, she would, for several days at a time, have frequent attacks of typical paroxysmal asthma with very sudden onset, which lasted from ten to twenty-five minutes. The night-nurse, sitting at her table in the ward corridor, could hear the asthmatic breathing as it began, and would hurry to give her an hypodermic injection of 5 minims of adrenalin. This was repeated often three or four times a night. During these attacks her appearance was pathetic; crouched forward on the bed, blue from cyanosis, struggling for breath, unable to speak or even to stir. Then, for a few days, she might not have one attack.

October 10, 1920: No reaction followed the hypodermic injection of $\frac{1}{200}$ mg. of old tuberculin.

October 19, 1920: The patient was vaccinated with milk, egg, and tuberculin in the order named. All were negative.

October 29, 1920: The patient had a very severe attack of dyspnea last evening which lasted two hours or more.

November 12, 1920: The patient's tonsils were removed. They proved to be quite infected. The improvement in the respiratory symptoms which followed this operation, and which lasted for several days, was surprising, and high hopes were entertained that a subsequent necessary operation on her nose might bring still greater relief.

November 24, 1920: The patient was vaccinated with the proteins of egg, wheat, and horse-dandruff. Two controls were made in each case, each 1½ in. on both sides of the original vaccination. Neither the egg nor the wheat gave any reaction, but the horse-dandruff gave a distinct reaction, a wheal 1½ in. in diameter rising around the original point of vaccination.

No reaction followed the subdermic injection of an autogenous vaccine prepared from the bronchial sputum.

She reacted positively to rabbit hair, Staphylococcus pyogenes aureus (slight reaction), Staphylococcus pyogenes citrus (slight), salmon and tomato; but negative to goose-feather, Staphylococcus pyogenes albus, rice, rye, squash and sweet potato.

The patient says that she has handled rabbits and does not believe they aggravate her condition, while goose-feathers have caused violent paroxysms of asthma. She was sure that tomato soup has on many occasions benefited her.

FIG. 5. Mar. 12, 1921. Stereoscopic plates of chest show a slight change in the right chest, the lung having expanded slightly in the region of the sixth and seventh interspaces. The upper and anterior chest walls show a peculiar elongated dark shadow which appears as a tear in the parietal pleura. There are adhesions around it. Interpretation of this seems difficult. The left border of the mediastinum shows some increase of air, there being a dark shadow that seems to cap the heart.

FIG. 6. Stereoscopic plates of the chest show about the same condition of right chest, with possibly slight increase in fibrosis. The area described in last examination as a tear of parietal pleura located in upper anterior chest has increased in size until now it covers an area of considerable size.

December 14, 1920: The tests were slightly positive for the proteids of wheat, oyster, peanut, pork and casein; distinctly positive for cat-hair (3 plus), cattle-hair (3 plus), potato (?), Brazil nut, carrot (?) and cheese (?); but negative for turkey, veal, English walnut, pea, bluefish and buckwheat.

December 17, 1920: The protein tests for lentil, lamb, lima bean, lobster, mackeral, mustard, corn, crab, eggplant, egg white, egg yolk and lactalbumin all were negative.

November 24, 1920: A right-sided partial pneumothorax was unexpectedly discovered by means of roentgenograms. These plates had been taken as a matter of routine. In tracing back her history, no clue could be obtained as to the date of origin of this condition. Indeed, it may have been present for a long time. This discovery led to several much more careful examinations of the chest. It was thought possible that the right side did lag a little in the movements of respiration, and that the interspaces on the right side

FIG. 7. Apr. 23, 1921. Stereoscopic films of chest, postmortem, show the same extensive pneumothorax and adhesions on the right, with the heart and mediastinum displaced to the left. There is a slight suspicion of an area of pneumothorax in the posterior part of the left upper lobe. The main bronchus on the left seems extremely dilated and prominent, with very prominent trunk areas. The lung on the left contains so much air that it has the same appearance as the opposite chest. There is the appearance of a double pneumothorax.

were more noticeably obliterated than on the left side. Litten's sign was absent on both sides. Fremitus was felt over both apices posteriorly, perhaps a little more distinctly on the right than on the left side. Both sides were hyperresonant on percussion, but the note over the right side may have been a little more tympanitic than that over the left. The lower posterior limits of pulmonary resonant were at about the same level. The breath sounds in general were loud and blowing with expiration much prolonged and accompanied by whistling rales heard over the entire chest during both inspiration and expiration. They were unusually loud over the left apex, over which area expiration was much prolonged. Whistling and musical rales were heard over the left lung. The breath sounds were perhaps more distant over the right lung and had an amphoric quality. The whispered and spoken voice were well heard over the base of the right lung, but were distant over the left lung. The coin sound was a little more distinctly heard over the right lung at the base and in the axilla than over the corresponding area of the left chest, but this was by no means definite and the typical coin sound certainly was absent. No splashing could be heard on succussion. We would emphasize, however, that these signs of pneumothorax were not at all definite, and that the examinations were made with the full knowledge of what the plates showed.

The urine on all occasions was quite normal, containing no albumin, no sugar and no casts. The red blood count was 6,000,000 and the hemoglobin 90 per cent. The leucocyte count, on September 28th, was 9,000 per c. mm., of which 12.4 per cent were eosinophiles. In another count, later, 14.6 per cent of the leucocytes were eosinophiles. The temperature frequently rose to 99° to 100° F. in the afternoon; the pulse varied from 80 to 128, and the respirations were about 24 per minute.

The patient, feeling better, went to her home on January 8, 1921, but soon returned in great respiratory distress.

Second admission, Feb. 10, 1921.

March 19, 1921: "The patient at 6:30 this morning had a very severe attack of asthma. Four minims of adrenalin hypodermically relieved her for about half an hour. Then followed a second attack of dyspnea which lasted about fifteen or twenty minutes. She is more comfortable when well propped up on a back rest, her bed in front of an open window."

March 21, 1921: "The patient's dyspnea is not quite as marked. Her respirations are 24 per minute."

April 8, 1921: "Patient seems much better; her respirations seem much easier than usual."

April 18, 1921: "The patient is not doing well. Her attacks of dyspnea are more frequent and more severe, especially during damp weather."

Fractional gastric analysis showed on one occasion (February 25, 1921) no free hydrochloric acid and a low total acidity which varied from 14 to 33 acidity per cent. Another examination, on March 5th, gave a total acidity of 68 and free hydrochloric acid of 25 acidity per cent.

The sputum, frequently examined, contained no elastic tissue and no tubercle bacilli.

The urine was always normal, its specific gravity varying from 1.010 to 1.022, and it always was free from albumin and sugar.

Between February 10 and March 17, 1921, the temperature ranged between normal limits, the pulse between 86 and 122, and the respirations about 24 per minute.

One blood-count during this admission was: Red cells, 5,448,000; leucocytes, 8,600, of which 79.5 per cent are polymorphonuclear finely granulars, 7 per cent small mononuclears, 1.8 per cent large mononuclears and 11.6 per cent eosinophiles.

April 22, 1921. Final note. "The patient has been losing ground for eight or nine days; the dyspnea has been almost constant and attacks with cyanosis have been frequent. This evening, while on the bedpan, she experienced a sudden increase of the dyspnea with cyanosis, and died in fifteen or twenty minutes."

Autopsy. Anatomical Diagnosis. Bilateral pneumothorax, complete collapse of right lung, partial collapse of left; bilateral fibrous pleuritis; moderate thickening of bronchial mucosa in the larger bronchi; generalized passive congestion; healed mitral endocarditis; chronic appendicitis; moderate fibrous thickening of the gall-bladder with slight scarring of the adjacent liver tissue; distention of chest; visceroptosis.

The body is that of a slightly-built, adult, white woman, about 5 ft. tall and weighing about 90 lbs. There is marked cyanosis of the finger-tips and head back of the ears and neck. The superficial lymph-nodes are not palpable. The chest is expanded and barrel-shaped. Subcutaneous fat is scanty. The skeletal muscles are normal in color. Peritoneal surfaces are markedly congested and of a purplish color. The liver margin reaches about 10 cm. below the xiphoid cartilage in the midline and on the right side below the level of the iliac crest. The diaphragm is low, at the sixth interspace on the right and at the seventh on the left side.

There is an escape of free air on opening the right pleural cavity which was demonstrated by the water test. The same is true of the left pleural cavity.

There is no free fluid in the peritoneal cavity. There is marked congestion in the region of the appendix, which is bound down retrocecally. There are no adhesions in the peritoneal cavity.

The right lung is totally collapsed. It is adherent to the chest wall about its apex and anteriorly and posteriorly over its lower lobe.

The left pleural cavity shows many adhesions. The anterior margin of the left lung is markedly distended and emphysematous. The lower lobe of this left lung is partially collapsed; its posterior portion is deeply congested, purplish red in color and contains but very little air. On section it shows a glassy appearance, is uniformly congested, but contains no free fluid. The mucosa of the bronchi is congested and in areas appears thickened.

The right lung contains no air, is of a deep, purplish red color, is markedly congested and resembles spleen in consistency and color. A fragment barely floats in water. There is moderate congestion of the bronchi.

There is no evidence of tuberculosis in either lung.

The myocardium is rather fibrous, but shows no other visible changes.

The gall-bladder is adherent to the liver substance and to the mesocolon. Its wall is slightly thickened. It contains about 15 c.c. of bile, but no concretions.

The liver is normal in size and shows no changes on section. There are a few superficial scars in its capsule in the region of the gall-bladder.

The pancreas is deeply congested and rather soft. There is capillary extravasation of blood within the pancreatic substance.

The left kidney is rather small, weighs about 125 gm., and on section has a deep, cyanotic, red color. Its capsule strips with normal resistance. Fetal lobulations are visible over its surface. There are a few scattered subcapsular scars, but no other gross changes. The right kidney resembles closely the left.

The gastrointestinal tract shows no visible changes except marked congestion.

The uterus and appendages are markedly congested, otherwise normal. The adrenals are normal in size and appearance, with no loss of the yellow pigmentation of the cortex.

This, then, is the case of a young woman twenty-two years of age, who, since she was two and a half years of age, was practically invalidated by very frequent attacks of true paroxysmal asthma, a tendency which she apparently had inherited from both her father and her mother. This asthma led to marked chronic hypertrophic pulmonary emphysema. We have no evidence whether or not she inherited also a tendency to emphysema. One result of the latter condition was a chronic partial pneumothorax, so latent that it was not suspected until the roentgenograms of her chest were studied. Even after we knew of its presence, we could get no history which suggested the date of its onset. It certainly was present for months before her death. We feel justified in believing that her sudden death followed the sudden development of a double pneumothorax while she was straining at stool a few minutes before her death.

While well over 90 per cent of all cases of pneumothorax are due to pulmonary tuberculosis, yet we feel we can rule out the presence of that disease in this case, since during life and at the autopsy especial attention was paid to this point, and no evidence of, or lesions of, pulmonary tuberculosis could be found. We believe the double pneumothorax of this patient was due to chronic hypertrophic pulmonary emphysema. It is not at all surprising that this disease should lead to pneumothorax; the only wonder is that it does not more often do so. In chronic hypertrophic pulmonary emphysema, the disappearance of the septa between many adjacent alveoli results in the formation of large air spaces, or blebs, each the sum of many alveoli. The superficial blebs have the pleura as external wall, and the nutrition of this membrane over these blebs is certainly hazardous, since the normal pleural membrane receives its nutrition from the underlying lung tissue. The inevitable result of the disappearance of groups of underlying septa with their blood-vessels must be a progressive atrophy of the pleural membrane at these points, from lack of nutrition. This will progress until finally it becomes so weak that it can be ruptured by even an ordinary respiratory movement. Such must be the explanation of those spontaneous non-tuberculous cases of pneumothorax which develop during sleep, although more often as the result of some spasmodic effort such as laughing, coughing, sneezing, jumping from a chair, dancing, running up stairs, straining at stool, etc. In the case of those previously healthy, however, the bleb must have been the result of interstitial emphysema rather than of the chronic hypertrophic variety. One should remember that it is the pleura which protects the pleural cavity from pneumothorax, since undoubtedly the lung tissue is frequently ruptured by coughing and other strains. As the result of such rupture, the air escapes into the interstitial lung tissue, lifting the pleura into blisters torn free from the underlying lung. So difficult is it to rupture the pleura, that in cases with severe paroxysmal cough and in the strain of parturition, the air will dissect its way along the bronchi into the mediastinum and then through the suprasternal notch into the subcutaneous tissue over the chest wall, and yet none find its way into the pleural cavity. These blisters of pleura freed from the underlying lung tissue and its vessels must explain the great majority of spontaneous pneumothorax which develops in quite healthy persons, even months after the least physical strain. In cases of chronic hypertrophic emphysema such as this girl had, the *bullae* present may be even as large as a pigeon's egg.[1] The fact that the emphysematous lung had lost practically all its elasticity hindered its collapse, and therefore, until

[1] HUGHES. *Guy's Hosp. Rep.*, 1852–3, 2d s., viii, i.

the last day, probably prevented the formation of a complete pneumothorax. The facts that the pneumothorax was partial and that the emphysema alone caused such respiratory distress explain why the condition was so latent.

While emphysema is the proven cause in relatively few cases of pneumothorax,[2] this is, so far as we can ascertain, the only case on record of double pneumothorax due to emphysema.

DISCUSSION

DR. LEWALD. We have had three cases of spontaneous pneumothorax nontuberculous. The first case occurred in a man who was taking a cold shower and collapsed. He had been examined just a few days before for life insurance. He was twenty-five years old, and his lungs at that time were perfectly normal. He made a complete recovery in about four weeks. He was put on some physiologic respiratory movements to try to expand the lung, such as blowing on the bottles. He never had any recurrence, and never had any tuberculosis develop. He was examined for a period of two years.

Another case was in a messenger boy who was running across the street and collapsed. He was taken to the hospital, where it was found that he had a spontaneous, or perhaps not quite spontaneous, pneumothorax. That lung also expanded, but it took a longer time—about six weeks.

The third case was in a younger subject, a boy of about nine years of age, in which we had no history of forcible effort. It was on the right side, pushing the heart over to the left, much as in the preceding case. He was watched for six months and the condition did not clear up. That brings up the point that was brought up in this case—how long can a pneumothorax exist before being discovered in routine examination? I think the point is that there are many cases of nontuberculous pneumothorax.

DR. KEITH. We have seen three or four cases of this kind. One case occurred in a child with diphtheria followed by exertion. The child died a few hours after the plate was made. That was an acute infection.

Another case was that of a little fellow, two and a half years of age. The clinician, who was called to see another member of the family, noticed that the little fellow was out of breath. He brought the child into the office and was unable to make a diagnosis. This child had a collapse of the lung on one side. The plate showed a very definite adhesion of the pleura at about the junction of the upper and lower lobes. We rayed him again three or four weeks after, at which time the lung had begun to expand. A plate two months after showed a complete recovery. This child had nothing except a little cold.

In the other patient, according to the history, the collapse of the lung occurred while she was mountain-climbing in Colorado twelve years before. She had a little trouble immediately after, lasting three or four days, but no trouble subsequently. At the time we saw her she had no symptoms. The plate showed the collapse still present.

DR. CRANE. Dr. Beeler, in his paper, mentioned the fact that the lung tissue may be frequently ruptured when pneumothorax is not produced. This may cause the annular shadows we see in the lungs which we are inclined to call cavities, even when there is no disease evident. If that is true, there may be some danger, when these annular shadows are seen, from spontaneous pneumothorax. In one of the slides which Dr. Beeler showed, there was just a beginning separation of the lung near the apex, which showed very clearly the line of the pleura, and suggested Van Zwaluwenburg's pleural gap. We would think from that line which showed so clearly, that Van Zwaluwenburg's gap was in reality the line of the pleura. In this case it was not because it was thickened, but because the lung had begun to collapse; however, it would help to interpret the shadow which Van Zwaluwenburg has so well explained.

DR. POTTER. I think the point Dr. Beeler brought out about the strains that brought on this rupture is interesting. We can easily see how we can get greater intrathoracic pressure from closed-mouth strain than from a cough where outside air is present. The case I saw was a young man who was supposed to be perfectly well. He was cranking a six-cylinder car on a cold night, and did not succeed in getting it going. He had just a moderate pain in his chest, a little bit of shortness of breath—enough to make him see his doctor, who was a very good internist. This was not recognized as a pneumothorax, and he was advised to go down to Asheville and play golf, and maybe he would feel better. He did so, but did not feel better. He would feel a little worse when he got halfway around the course. He came home and went to another internist, who said, "You have a collapsed lung."

It is difficult to make out, from *x*-ray examination after the lung is collapsed, whether it is

[2] EMERSON. *Johns Hopkins Hosp. Rep.*, Vol. xi.

due to a thinning out of the mediastinum or to a small amount of disease; because after the lung is collapsed, it looks more or less solid and a small amount of disease can be there and not be seen. It is interesting to try to see it. When the patient breathes in, you see the lung absolutely fill up, and when he breathes out, it sinks again at the hilus. You can, during that inspiration, perhaps, get some idea whether there are consolidations inside the lung. After the condition has cleared up, you may be able to say whether there was any disease in the region of the tear.

DR. HICKEY. I would like to ask Dr. Beeler if he made any fluoroscopic studies on this case, and if he did, whether he was able to demonstrate the lateral movements of the heart with respiration. We have one case of artificial pneumothorax where this is quite a striking phenomenon. I wondered if it were true in the spontaneous.

DR. MURPHY. I would like to ask if anyone has had experience with pneumothorax with fluid, and if there is any possible way of clearing up the fluid. We have a case in which by positive pressure apparatus we were able to bring the lung back to normal, but the fluid continues to form, and fills the chest almost as fast as we can take it out.

DR. BEELER (closing discussion). I forgot to mention that the cause of death in this case was double pneumothorax.

In answer to Dr. Crane as to the Van Zwaluwenburg gap, I admit that that is what we thought we had, and from the plates and stereoscopic studies, I would have almost sworn that she had tuberculosis. I saw the autopsy made by the University pathologist, who is a very competent man. Thorough sectioning showed no tuberculosis in any part of the lung.

In answer to Dr. Hickey, I will say that we did fluoroscope the case several times, and were unable to see any movement of the heart. Whether that was due to the number of adhesions that were found, I do not know, but we were unable to show any change in the lateral position of the heart.

ANATOMICAL CROSS-SECTION CHARTS IN ESTIMATING X-RAY DOSAGE*

BY ARTHUR U. DESJARDINS, M.D.

Section on Radium and Roentgen-Ray Therapy, Mayo Clinic

ROCHESTER, MINNESOTA

THE day of haphazard radiation therapy is rapidly passing, as more precise facts are emanating from the laboratories of the physicist and of the research pathologist; and the application of such facts is making more necessary the development of a technique in which methods of precision play an increasingly important part.

As recently stated by Ledoux-Lebard, the idea of treating deep lesions, and particularly malignant tumors of the viscera, by means of *x*-rays, is nearly as old as radiotherapy itself. The fundamental laws governing the action of the rays on tissue cells were laid down years ago as the result of the experimental studies of Albers-Schönberg, Bergonié, Tribondeau, Halberstädter, Regaud and Blanc, Lafargue, Cluzet, Nürnberger, Hudellet, and many others. The application of these laws to the treatment of various superficial lesions has been relatively simple, and has become a routine procedure. However, in lesions beneath the surface of the body, the results have not been so good.

The correct *x*-ray treatment of a given neoplasm requires:

1. Knowledge of the location, extent and type of the tumor, and its relations to surrounding structures, as well as of the existence and location of metastatic foci. It is often difficult, and sometimes impossible, to obtain such complete information.

2. Knowledge of the quantity of rays of a definite quality, or "effective wavelength" necessary to deal successfully with a given type of tumor. A great deal is heard about the so-called "cancer dose," but our knowledge of dosage is not sufficient to warrant the use of such a term. If we are asked what is the cancer dose in a given case, we must admit that, thus far, there is no such dose, and it is doubtful if

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there will ever be. This is true, because we do not know enough about the biophysical and pathological phases of tumor growth, and we know still less, if anything, about the quantitative and qualitative effects of *x*-rays on different tumors of the same type. To discuss this at length would be beyond the scope of my subject.

"effective wave-length." As the result of the introduction by Villard and Szilard, of the ionization method of measuring the intensity of a beam of *x*-rays, we are now in position to determine, at different depths in the tissue, the percentage penetration of the beam striking the surface.

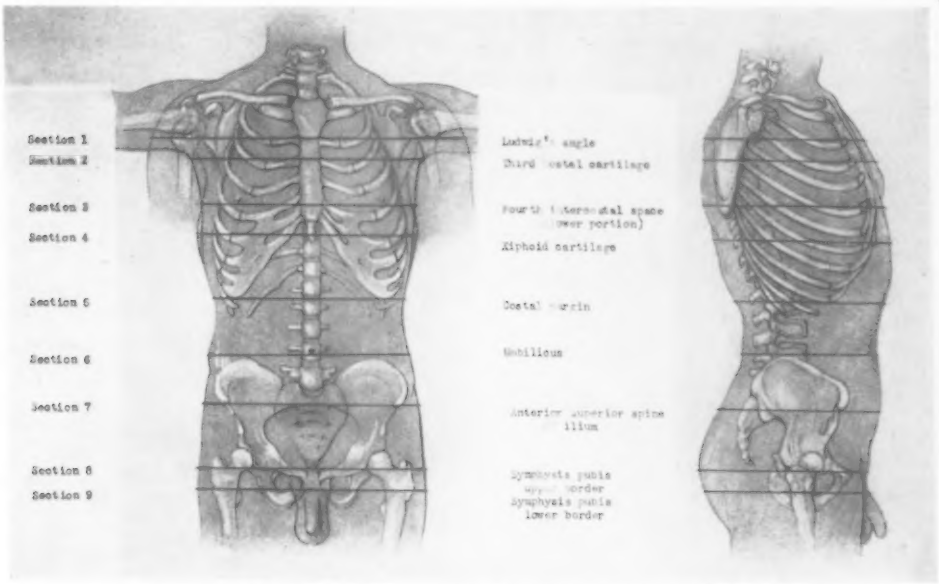

FIG. 1. Levels at which contours and sections were made in male.

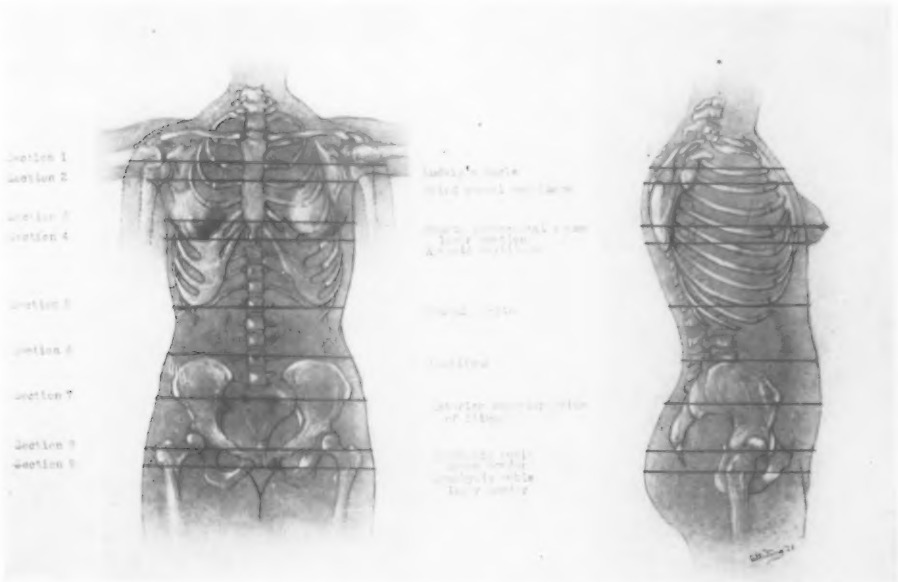

FIG. 2. Levels at which contours and sections were made in female.

3. Knowledge of the absorption or penetration characteristics of rays of a given

Whether the radiologist chooses to utilize the well-known penetration charts of Dessauer, or whether he prefers to

work from data obtained by his own efforts, and with his own apparatus (this is undoubtedly the better method, provided the radiologist be trained in the use of physical instruments) the intelligent use of such data in a given case requires fairly accurate knowledge of the distance of the tumor from the surface, and as much as possible of the dimensions of the tumor, including foci of dissemination. This involves measuring the patient at the level of the growth preferably in the form of a contour sketch, with relation to which penetration data may be studied.

In this connection it occurred to me that life-size cross-section charts of the average male and female figure would be very desirable, and would enable the radiologist to study his penetration data, and to determine the ratio of depth dose to skin dose with relation to the average human figure.

Anatomies showing cross-sections are now available, but the sections were made from dead subjects, and present a variable degree of distortion. In only one such atlas, to my knowledge, are the sections life-size, and these were made from one body only.

In order to fulfill the foregoing requirements and to meet the objections, a series of life-size cross-section charts of the trunk of the average male and female body were prepared. To obtain such an average, or what might be termed "ideal" male and female figures, twelve well-formed male, and twelve female subjects, were selected varying in weight between 100 and 200 lbs.; in height, between 64 and 74 in.; and in age, between twenty-five and forty years. Of each subject, a series of careful contour measurements at different levels was made. For obvious reasons, the levels selected correspond to prominent and easily recognizable surface landmarks. Figures 1 and 2 show the levels at which the contours were made.

FIG. 3. Composite contour tracing of twelve female subjects at the level of the lower portion of the fourth intercostal space.

The number of levels measured and charted is thought to be sufficient for most purposes, although in foreign body

localization, it might be desirable in some cases to have a larger number to cover intervening points.

The contours at each level were then brought together, and a composite made at each level for the twelve male and for the twelve female subjects, and from each of the composites an average contour was traced. Figure 3 shows one of these composite contour tracings, and also the "average" contour traced from it.

The method employed in making the contour tracings was as follows:

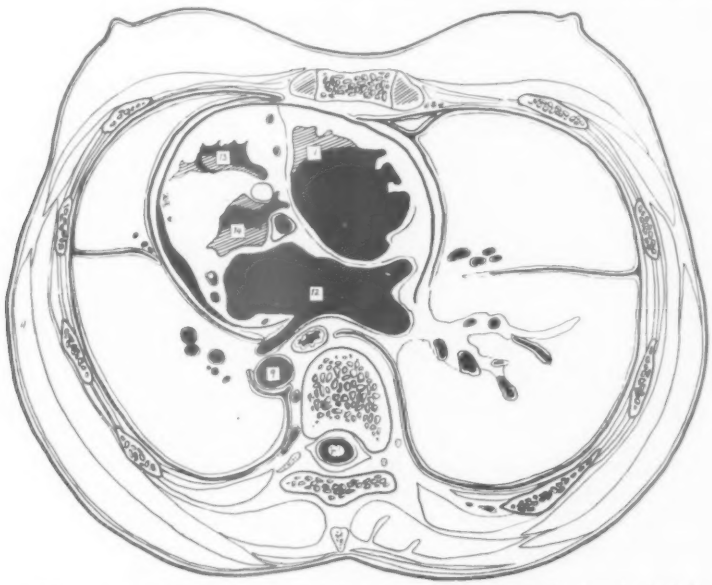

FIG. 4. Contour and cross-section of the average female at the level of the lower portion of the fourth intercostal space.

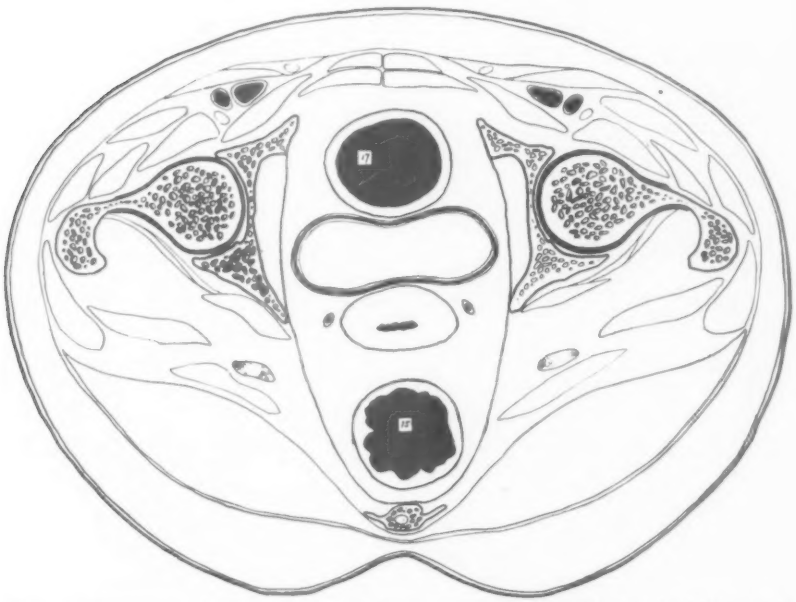

FIG. 5. Contour and cross-section of the average female at the level of the upper border of the pubic symphysis.

The subject was instructed to stand straight, with feet well together, but with no muscular effort. The level was determined and indicated on the skin. A piece of rubber tubing was passed over a heavy

lead wire, the whole being readily malleable and yet stiff enough to hold any position. The median line having been determined at a given level, the middle of the lead wire was placed in contact with the skin at this point, a corresponding mark being made on the rubber tubing. The ends were then molded to the surface, an assistant maintaining the contact behind as the wire was adjusted anteriorly, where the mid-line was similarly determined and marked. After it had been determined that the contact was perfect checked in these two dimensions, after which the contour was traced on the paper.

In charting the outline of the internal structures, information was gathered from several standard anatomies, such as Gray, Deaver, Piersol, Spalteholz, Sobotta and McMurrich, and the cross-section charts of Professor Symington and of Professor Eycleshymer.

More or less discrepancy exists in the description by different anatomists of the location of certain structures, such as

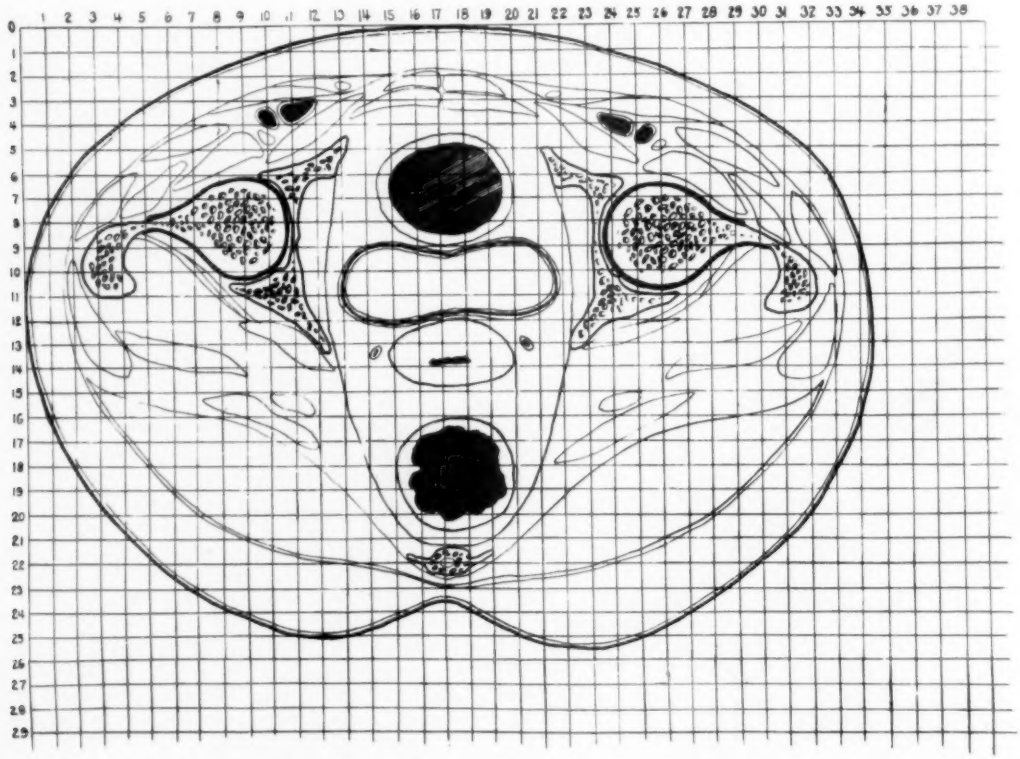

FIG. 6. Shows how the measuring chart makes possible measurements of any portion of the cross-sections.

all around, and free from undue pressure, the effect of respiration was studied in order to learn as accurately as possible the point midway between ordinary inspiration and expiration.

The wire was then removed, by slipping either upward or downward, and transferred to a sheet of paper. Before tracing the contour on the paper, careful measurements of the anteroposterior and transverse diameters of the body at that level were made by means of a large caliper, and the contour as represented by the lead wire

the umbilicus. This is not at all surprising to one who has examined a number of dead bodies. Eycleshymer places the umbilicus opposite the intervertebral cartilage between the third and fourth lumbar vertebrae. Davis places it opposite the intervertebral cartilage between the fourth and fifth lumbar vertebrae. As a matter of fact, in the average body the umbilicus is to be found opposite some portion of the fourth lumbar vertebra.

Another example of such discrepancy is to be found in the female breast. There is a

very considerable difference in the size of the breasts and in the tonicity of their tissue components; this accounts for a wide variability in the location of the nipple.

A striking instance of variability in location may also be seen in the uterine cervix, the exact position of which varies with the degree of distention of the bladder, the state of the rectum with regard to its contents, the position of the uterus itself as affected by lacerations of the pelvic outlet, and other pathological conditions around the pelvis. In all such instances an endeavor was made to strike an average between the extremes.

Figure 4 shows one of the charts of the female thorax at the level of the lower portion of the fourth intercostal space. On looking at the actual chart (this is not apparent in the reproduction) the first thought that comes to one's mind is: "That cannot be a true section of an average-sized woman; it looks too small."

Figure 5 is a section of the female pelvis at the level of the upper border of the pubic symphysis—the level corresponding to the junction between the cervix and body of the uterus. Again, one is struck by the apparently small size of the section. That impression obtains throughout and is especially striking in connection with the sections in the region of the lower thorax and upper abdomen. The charts all look small compared with one's conception of the size of a human being. Contour measurements of a large man or woman weighing 200 lbs. will invariably look much smaller than one would expect from the appearance of that individual. However, if the section circumference be measured, one will soon be convinced that appearances are deceptive.

These charts will assist the radiologist in applying or studying penetration data with relation to the average patient, but will not remove the necessity or advisa-

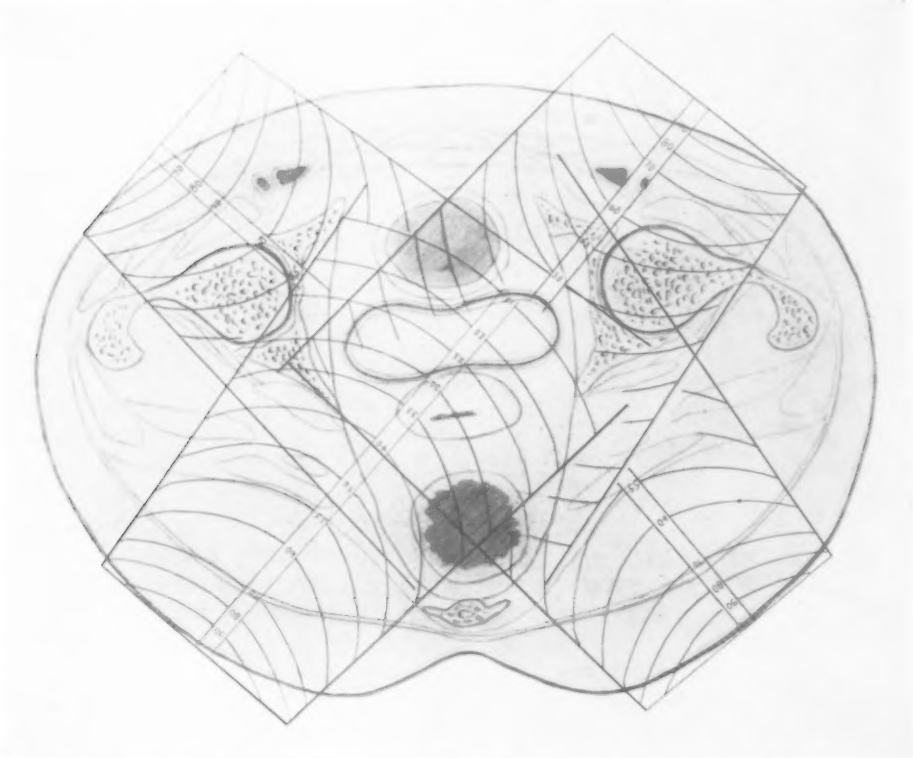

FIG. 7. Contour and cross-section of the female pelvis (upper border of the pubic symphysis) studied with relation to Dessauer's penetration data: kilovoltage 181.5; ma. 2; filter 0.8 mm. copper and 1.0 mm. aluminum; distance 50 cm.; size of field 10.1 cm × 13.4 cm. Owing to the confusion produced by extending all four cones through the uterine region, only one complete cone is shown.

bility of measuring patients, especially such as are patently larger or smaller than the average.

By means of a measuring chart graduated in centimeter squares and printed on transparent celluloid, it becomes a simple matter quickly to obtain any measurements desired. Figure 6 illustrates the use of the measuring chart.

Figure 7 shows the section of the female pelvis, at the level of the upper border of the symphysis pubis, studied with relation to Dessauer's penetration data under the following conditions: kilovoltage at tube terminals, 181.5; ma., 2; filtration, copper 0.8 mm. and aluminum 1.0 mm.; anode-skin distance, 50 cm.; size of field, 10.1 × 13.4 cm. From this it may be seen that for each field treated, about 30 per cent of the surface dose penetrates to a depth of 15 cm., roughly corresponding to the position of the uterus with the rays focused at the angle shown. If we may accept Dessauer's values as at least approximately accurate, treatment through four such fields will enable us to deliver a fairly uniform dose representing 120 per cent of the skin dose taken as 100 per cent.

There are so many methods of foreign body localization that no attempt is made to show their use in conjunction with the charts.

INJURIES FROM ROENTGEN RAYS IN DEEP THERAPY*

BY HERMAN WINTZ, M.D.

ERLANGEN, GERMANY

THE results obtained during recent years by the employment of deep roentgen therapy have fully justified the claims made for this newer form of treatment. Though it may be said to be still in its infancy, I venture to predict that the successes obtained by this mode of treatment will increase from year to year.

The introduction of a new therapeutic measure has always been accompanied by an over-estimation of its curative powers, which, in the course of time, had to be modified when a more mature judgment prevailed. In deep roentgen therapy we are threatened with a set-back on account of a variety of injuries resulting from the therapeutic application of the rays.

For this reason, I think the time has arrived to arouse a general interest in the dangers involved in deep roentgen therapy and to call attention to the dangers inherent in the agent, and not attributable to its careless use.

It is not necessary to refer to those phenomena with which every roentgenologist is sufficiently acquainted—the so-called "*x*-ray burns." They are the results of overdoses which exceed the limit of tolerance of the exposed tissues, and which, in the majority of cases, are attributable to the careless or unskilled handling of a roentgen apparatus or to technical defects in the appliance, such as a non-functioning milliampèremeter or a faulty chronometer.

It must be expected that a conscientious and expert roentgenologist manipulates his apparatus so skilfully that he will notice such disturbances at once, and that he will not entrust his work to poorly-trained attendants. *X*-ray burns should not occur under an expert management. However, roentgen injuries have occurred and will occur in the future, and cannot be avoided with absolute certainty. But it is also true that certain accidents may happen after surgical interference.

These injuries may be divided into two groups: local and general injuries.

I. LOCAL INJURIES

1. *Injuries Caused by Exceeding the Limit of Tolerance of Tissues, and Resulting from the Defects of Our Present Radiation Technique.* The medical technique of the deep roentgen therapy is based on the fact that it is almost never possible to apply, through a single field of entrance, the amount of rays necessary for the destruction of a malignant tumor. Hence, multiple ports of entrance are necessary. This requirement, however, contributes to the

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12-16, 1922.

danger of overdosing, regardless of an otherwise exact technique. This danger is augmented by the fact that the dose of roentgen rays necessary for the destruction of the carcinoma (carcinoma dose) represents a quantity of rays which approaches the dose that can just be tolerated by the mucous membrane of the large intestine and the bladder. These posological difficulties are increased by the fact that the quantity of primary rays introduced into the body is being increased or lessened in a manner not easily determinable by the size of the irradiated body volume and its varying density. The latter depends on the varying composition of different parts of the body.

For the irradiation of the body, those values are generally selected which have been obtained by measurements in the water phantom. It is evident that the diffusion of rays in a known volume of water cannot be identical with the diffusion of rays in a like volume of the body which may contain the muscular apparatus, the gall-bladder, the intestines with extraneous contents, and the bladder. The latter, particularly, is being gradually filled during irradiation. In the radiation, through different fields of entrance, of cervical cancer which lies at an average depth of 10 cm., the sources of error just mentioned are compensated for. But conditions are quite different for the superficial layers of tissue.

Based on results of radiation measurements in the wax or water phantom, and on the cadaver, we treat cervix cancers through 6 or 7 fields of entrance, each field being 6 by 8 cm. These fields of entrance must, of course, be placed close together, as shown in Figure 1. If the skin in each case is exposed to 100 per cent unit skin dose (U.S.D.) there will remain an intensity of rays of 65 to 70 per cent of the U.S.D. at a depth of 2½ to 3 cm. The intensities of rays at the adjoining sides of 2 fields of entrance are increased by a summation of the lateral intensities of the 2 fields to which eventually must be added a third field, the vulvar field. Therefore, it is almost impossible to avoid raying some parts of the anterior wall of the bladder by a quantity of rays which approximates 150 to 160 per cent of U.S.D. If, during radiation, the bladder is not emptied at least every hour, the fundus vesicae, or rather the anterior wall of the bladder, will be forced closer to the anterior abdominal wall, and thereby nearer to the roentgen tube. The quantity of rays striking the anterior wall of the bladder will then be still further increased. In the latter instance an injury will occur, manifesting itself principally in blistering and an edema of the vesical wall. A real burn and the formation of an ulcer in the mucosa of the bladder may also take place. As the muscles bear a stronger dose than the mucous membrane, only the epithelial coat of the bladder will be injured.

FIG. 1. Location of fields on suprapubic region.

The rectal mucous membrane is also subject to similar injurious factors. The anterior wall lies close to the portio, and all the cones of rays are focused on it. If the radiation is carried out carefully, the anterior rectal wall will not be endangered. However, the posterior wall of the rectum lies within reach of at least 3 fields of entrance. In thin patients, the region of the posterior rectal wall may be exposed to a radiation dose of about 140 to 150 per cent of the U.S.D.

Experience teaches that this overdosing will occur only in small isolated areas of the mucosa, and ulcers will form. But it is also possible that ulcers may secondarily result from vascular injuries and, eventually,

from the secondary rays which arise in the contents of the bowel.

An *x*-ray injury of the small intestine, due to the overlapping of several radiation cones, is rarely observed, owing to the fact that the small intestine is mobile and easily pushed out of the field of irradiation at each new adjustment of the compression tube. But if several loops of the small intestines are fixed by pelviperitonitic adhesions either to each other or to the uterine tumor, a certain loop of the small intestine may be exposed to several cones of rays, and the same danger prevails then as described for the bladder and the large intestine. Various injuries have been observed in the small intestine. Some of the least serious are glandular atrophy, partial injuries of the vessels, partial necroses of the mucosa and ulcers of the mucous membrane. In general, injuries of the small intestines are less frequent, and, if occurring, are always due to one or the other complication. Injury to the lower portion of the ileum is the most likely to occur.

The mucous membrane of the small intestine is about 30 per cent of the U.S.D. less sensitive to the action of the rays than the mucous membrane of the large intestine.

If, in cases of mammary carcinoma, the supraclavicular glands and the lymphatic chains along the sternocleidomastoid muscle are infiltrated and, consequently, need treatment, an injury to the larynx and trachea is likely to occur. This danger is the more imminent if the right and left sides of the neck must be exposed to a dose of approximately 95 to 100 per cent at a depth of 2 cm. in order to affect the carcinomatous glands. If these 2 fields converge in the center, a dose of 150 to 160 per cent will strike the laryngeal mucosa. This dangerous dose applied to the larynx may be reduced by placing the patient in an appropriate posture and tilting and shifting the tube. But even then, the larynx will be exposed to a dose of rays lying between 120 and 130 per cent of the U.S.D. The injury will manifest itself by hoarseness and, eventually, complete aphonia, which may persist from two to four weeks; besides, there will be a sore throat and dysphagia. A somewhat larger dose (150 per cent) will render the laryngeal mucosa edematous and we are confronted with the danger of an edema of the glottis.

The injuries resulting from such a radiation can be lessened by raying each side of the neck separately, allowing an interval of several days between treatments. But in certain classes of cases this cannot be done, and it is particularly not advisable in the irradiation of a laryngeal carcinoma with carcinomatous infiltration of the adjoining parts. In such a case, separate radiations would mean a dissipation of the dose, and the dose required for the destruction of the carcinoma would be too small. Injury, namely, ulceration, results from the fact that the limit of tolerance of some of the elementary tissues is exceeded by the administration of too large a dose of primary rays.

2. *Injuries from Uncommon Secondary Rays.* There is another factor responsible for the occurrence of injuries: namely, the addition of a radiation intensity derived from uncommon secondary radiators. Thereby the radiation dose is increased though the primary radiation was correctly gauged and did not exceed the limit of tolerance of the tissues. We must always consider the possibility of such injuries resulting from the use of opaque meals: e.g., barium meals employed in fluoroscopy which have not been removed from the gastrointestinal tract by careful irrigation. Fecal masses may also act as generators of secondary rays. Furthermore, injuries to the bladder have been observed in cases in which collargol was injected into the bladder and the pelvis of the kidneys a few days prior to irradiation. Such injuries are, as a rule, trivial, because the fluorescent and beta rays emanating from the collargol (silver) are of low penetrating power. An illustration of an injury of this kind may be demonstrated by the following experiment: A healthy part of the skin is treated with "copperization." The process is executed as follows: A sponge electrode, saturated with a 5 per cent copper solution, is placed on the right side of the abdomen and an indifferent cathode on the back. A weak galvanic current of

20 ma. obtained from a storage battery is applied for four hours. The part of the skin which had been treated with copper is irradiated with an accurately measured dose of roentgen rays of 90 per cent of the normal U.S.D. (Iontoquantimeter—U.S. D.) The corresponding left side of the abdomen is also irradiated with the same dose. After four or five weeks we will observe on the left side of the abdomen a delicate yellowish-brown discoloration, corresponding to the margins of the field: while at the same time on the right side of the abdomen, where the copperization has been done, the skin exhibits a second degree erythema, which otherwise would have been attained with 120 to 130 per cent instead of 90 per cent of the U.S.D. (Fig. 2).

FIG. 2. Showing the more intense effect of *x*-rays on skin saturated with a secondary radiator than on untreated skin.

3. The Lowered Resistance to Injuries of Irradiated Tissues. The injuries described in the foregoing chapter are not surprising, for each overdose is bound to produce injuries to the tissues. In contrast to this, our observations show that every irradiated part of the body exposed to a quantity of rays exceeding the limit of tolerance typical for the cells by one-third, forms an area of lessened resistance towards irritants applied to it.

The knowledge of these *loci minoris resistentiae* is of paramount practical importance, for it explains the peculiar injuries which have been observed after correctly applied treatments, and particularly the so-called "late" injuries.

From a pathologico-anatomic viewpoint we are dealing principally with vascular changes. Changes in the metabolism of the cells are also quite probable. Such *loci minoris resistentiae* are observable in every irradiated part of the skin. We have established a dose of rays which is tolerated by the skin without producing any pathological changes: namely, a dose of 100 per cent of U.S.D. Irrespective of the fact that a pigmentation will appear on the irradiated area, after the exposure to the dose just mentioned, there will be observed neither a thickening of the skin nor an infiltration, nor even a desquamation. The pigmentation will slowly fade away in the course of two or three years.

If we employ a dose of less than 100 per cent of the U.S.D., e.g., 80 per cent, only a faint pigmentation is to be observed; and with a dose of less than 70 per cent, pigmentation will not occur. If to the effect of the *x*-rays upon the cells another irritant is added, which normally would cause no injury at all, the skin will respond to the summation of the two irritants with a distinctly recognizable reaction. Factors that may incite such a reaction are persistent pressure upon the irradiated part of the skin, the application of ice-bags, hot compresses, and chemical changes produced by the administration of internal remedies. To illustrate: The abdominal skin of an otherwise healthy (female) patient is exposed to 80 per cent of the U.S.D. About twelve to twenty-four hours after such an irradiation, a faint reddening of the irradiated part is to be observed (early erythema) which disappears after a short time. After four to five weeks, a delicate yellowish-brown pigmentation is to be seen in the irradiated part. If the patient takes a warm bath on the second day after irradiation, the early erythema will be considerably increased. After from eight to ten days another reddening will occur and the pigmentation also will be more distinct. The same effect may be produced by the application of an ice-bag or a hot electric pad or a hot-water bottle. By the employment of a dose of 100 per

cent U.S.D. the reactions will, of course, be stronger.

Irritants due to customs of daily life comprise pressure by the corset, waistband, bodice, and sometimes, braces. Such an instance of increased reaction in a part of the field of irradiation is shown in Figure 3.

This patient underwent irradiation for mammary carcinoma. The size of the dorsal field is shown on the photograph. On a level with the shoulder we note a pronounced brownness with desquamation. The picture conveys the impression that small fields of entrance had been employed in addition to and within the delicately

FIG. 3. Effect of long-continued pressure on a radiated area of skin.

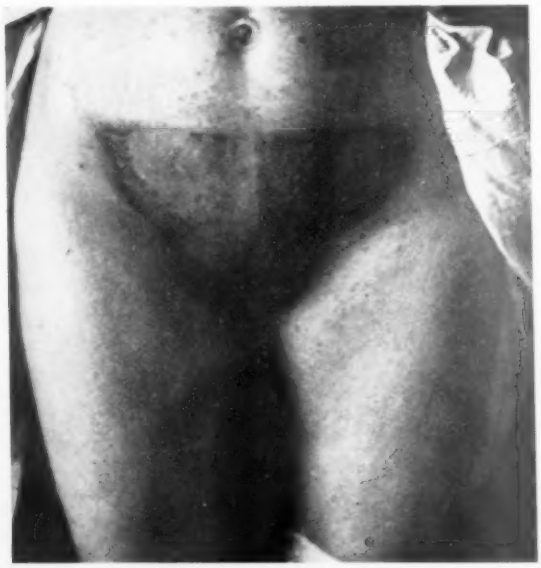

FIG. 4. Action of chemicals on skin exposed to a 100 per cent U.S.D. of *x*-rays.

browned large field of entrance. However, this was not so. The markedly pigmented spots correspond exactly to the straps of the basket which the patient used to carry.

Figure 4 shows a reaction which should correspond to the administration of a dose of rays of 120 to 130 per cent of U.S.D. However, in this case only 100 per cent of U.S.D. was employed. The dorsal fields show quite a marked brown pigmentation. The apparent overdose was due to the application of a concentrated solution of lysol which the patient sometimes used to wash the irradiated parts of the skin.

In the cases just mentioned, the injurious influences were but slight, and therefore followed by correspondingly weak reactions. It follows that severe traumata of irradiated parts of the skin may produce serious injuries. This fact readily explains the frequent occurrence of those startling "late" injuries. Thus we observed a case in which the skin area irradiated with 100 per cent of the U.S.D. received a strong blow with a heavy piece of wood. The result was a superficial necrosis, covering almost the entire field of irradiation. Even if such traumata occur from two to three years after irradiation, ulcers may develop on the irradiated skin which resemble those caused by burns. As a rule, they exhibit a better tendency to heal than the primary ulcers produced by over-radiating.

In discussing the causation of the *loci minoris resistentiae* we proceeded from the presumption that the irradiated part of the body was exposed to a single dose, from which a primary injury could not be expected. But if the same dose is repeatedly employed in the same part of the body, then the total of the macroscopically demonstrable injuries will produce a peculiar picture; namely, the roentgen induration. The skin, which was irradiated with a dose of 100 per cent of U.S.D., two, or at the most, three times, at intervals of from six to ten weeks, becomes leathery and thick, feels tough and hard, and

presents an edematous appearance. The cause of these changes is undoubtedly to be found in vascular injuries and an enhanced permeability of the vessels. The other tissues, including the muscles and the connective tissues, will also react in a similar manner. The power of resistance of tissue thus injured towards further additional injuries, such as traumatic and chemical noxae, or infection, is considerably lowered.

If during the period of the infiltration (induration) the skin is protected against all injurious influences, the condition will recede in from one to one and a half years. Far more dangerous is the infiltration of the pulmonary tissue which may appear after irradiations of mammary carcinomata or lung tumors. The examination findings of such a lung resemble those of a central pneumonia; there is no fever, but a slight irritative cough. The affected part of the lung is, of course, useless. This condition is also comparatively harmless and will recede spontaneously in the course of one-half to three-fourths of a year. If an intercurrent disease (pneumonia or bronchitis) complicates the radiation induration, then the prognosis is almost always bad (Fig. 5).

The prevention of the infiltrations of the pulmonary tissue is of decided importance if we wish to improve the results of radiation therapy of mammary carcinoma.

Just as the slightest injury following irradiation will increase the skin reaction, so acute or chronic diseases which are present in the tissue prior to the irradiation may incite an increased reaction.

A greatly increased reaction is to be noted with every gross change in the tissue, because the roentgen treatment introduces an additional noxious agent. Even when the skin is only slightly irritated, this increased reaction may be observed.

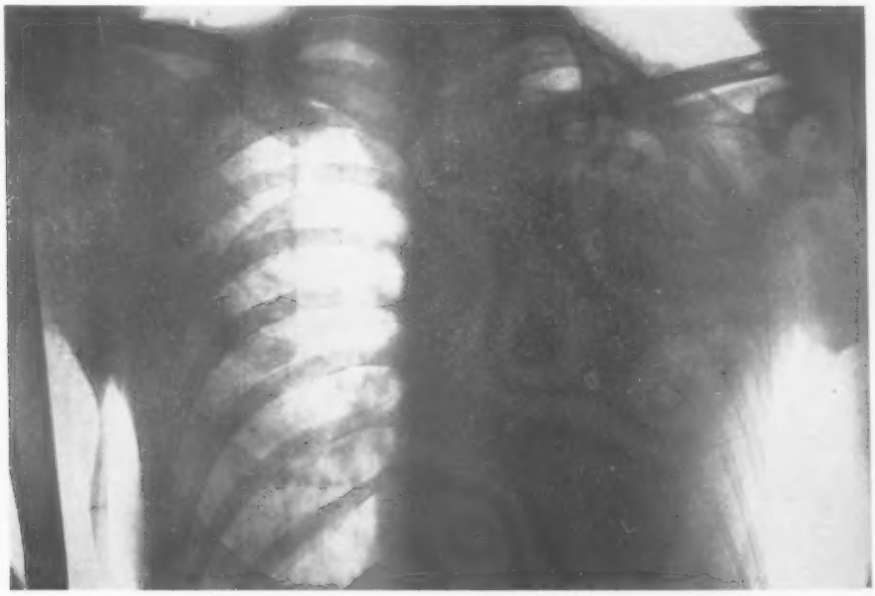

FIG. 5. Radiation induration of the lung.

Figure 6 shows a slight irritation of the skin in the anal region at that point in the field of irradiation where previously an inflammatory erythema was located. Attention is also called to the inflammatory reaction of the tissue in radiations of the ovaries when diseased adnexa exist. This explains the rise in temperature, as well as the slight parametric thickenings which are observed after the irradiation of myomata, climacteric bleedings or severe uterine hemorrhages. They are attributable to inflammatory adnexal disease. The reaction will be also increased if the cells are not visibly changed, and where a

systemic disease causes an injurious influence upon the cell. The investigations carried out by Seitz and myself demonstrate that the skin of Basedow patients is about 30 per cent more sensitive than the normal skin. The skin in certain varieties of diabetes is likewise more sensitive, and in lues also an increased reaction has been observed.

That copperization produces an injury to the cutaneous cells, and thereby an increased reaction of the skin, has been pointed out: the same may occur after a single long-continued galvanization of the skin.

FIG. 6. The more intense action of rays on erythematous skin area in comparison to that on normal skin.

Therefore, if a primary overdosing with *x*-rays can be excluded, and roentgen injuries occur, the possibility is that they were caused by a combination of injurious influences either before or after irradiation. The conception of "late" injuries is thus explained.

II. GENERAL INJURIES

Local injuries must be distinguished from general or systemic injuries. The latter may affect the patient as well as the roentgenologist and his employees. Omitting, for the present, the consideration of injuries due to unsuitable apparatus or manifestly careless manipulation of the same, as well as the traumata caused by high tension currents, burns and the like, there remain two factors which may be considered as typical roentgen dangers; namely, blood injuries and the inhalation of the air of the roentgen room and surges which can only be avoided by special devices.

Acute blood injuries result from acute destruction of the blood corpuscles. They follow a long-continued irradiation and are observed only in the patient. The chronic blood injuries affect the personnel, and are due to the effects of the *x*-rays as well as the "roentgen air."

Destructive changes in the blood occur during each therapeutic irradiation which is employed for the destruction of pathologic cells. The smallest quantity of rays introduced into the body corresponds to the dose ordinarily administered in castration irradiation. In order to determine the quantities of rays introduced into the bodies of different patients, it is necessary to express the quantity of rays by a new unit, for the posologic determinations hitherto in vogue refer to the amount of rays which act at the seat of the disease. Under given circumstances, a comparatively large dose may be measured in a certain part of the body, although the total amount of rays introduced into the body may be smaller than that which was administered at the seat of the disease.

The unit called "a" corresponds to the quantity of *x*-rays generated at about 180 kv., filtered with 0.5 mm. zinc, passing through a volume of tissue the size of a pyramidal stump, the upper surface of which is 6×8 cm., the altitude 15 cm., and the apex, i.e., the tube focus, is 23 cm. above the upper surface.

We must bear in mind that the kind of different tissues of the body also plays a rôle in these calculations. Our computations show that for the entire trunk these differences nearly compensate each other. If doses of from $2\frac{1}{2}$ to 3 "a" are introduced into the body, the first recognizable blood injuries will occur; these are easily counteracted by the body. Also a blood injury caused by 5 to 7 "a" will be overcome after from five to six weeks, provided that a hemoglobin content of more

than 40 per cent and an amount of leucocytes of over 2,500 existed before the radiation. In the castration irradiation, the amount of the dose is 4 "a," which, therefore, may unhesitatingly be administered to exsanguinated patients. The quantity of rays necessary for the irradiation of a uterine carcinoma is 6 to 8 "a," and does not result in an irreparable blood injury. For the mammary carcinoma we need up to 12 "a." Also with such a dose introduced into the body, a restoration of the blood picture to normal is regularly observed.

This comparison of the volume of the radiation cones leaves out of consideration the biological factors of the system. The most important are the functional capacity of the blood-forming organs and the ability to destroy the toxins (roentgen toxins and toxins resulting from the disintegration of the tumors). In a scientific investigation these factors must not be overlooked, nor the fact that the intensity of the *x*-rays within the time-unit is of importance. In a long-continued irradiation (roentgen therapy in one sitting with a large skin-focus distance) one may observe that the blood injury does not occur to a degree one might have expected, based on the computation made with the magnitude "a" previously described. This deduction is important because it shows that there exists an optimal irradiation period for distant radiations, and that the necessity of a great intensity of the rays within the time-unit is justified.

The injuries caused by irradiation also include the so-called "Roentgen Kater," the nausea produced by irradiation. This is not the place to enter upon the various discussions devoted to this condition. We only wish to state briefly that in the literature the view is being more and more advanced that the expression "Roentgen indisposition" is too mild for this general systemic disturbance. According to our findings—not taking into consideration the nervous factor, which plays an important rôle in "Roentgen indisposition"—actual changes in the biochemistry of the cells take place under the influence of the *x*-rays by an injury of the cell-lipoids. Furthermore, it is important to state that the charging of the patient with 3,000 to 4,000 volts, corresponding to the tension employed today, and the constantly occurring charges and discharges exercise decisive influence upon the function of the cells. Of practical significance is the fact that the roentgen indisposition is less severe or does not occur at all if the patient is either grounded, or, better still, is protected from the electrical charges by an appropriate screening (faradic cage).

The general injuries of the personnel are chiefly the chronic blood changes which appear with long-continued work with the *x*-rays. They consist of a rather high percentage of eosinophilic leucocytes (10 to 15 per cent) and of a leucocytosis (10,000 to 14,000).

The injurious agents to the personnel are mainly found in the air which has been vitiated by the electrical surges, and particularly by the ozone generated from the air by the *x*-rays. Direct exposure of the personnel to the *x*-rays should not occur in a well-conducted *x*-ray laboratory. Finally, it might not be amiss to point out that defectively grounded lead-lined protecting partitions or badly arranged high tension wires may cause certain injurious influences. The danger consists in the fact that during irradiation an electric field is formed around the lead-lined walls within which the workers are either sitting or which they continually cross by walking around in the roentgen room. The charges and discharges thus generated in the cells of the body are liable to disturb the metabolism of the cells.

The above observations have disclosed quite a number of dangers inherent in deep roentgen therapy. However, many of them cannot be avoided, in spite of the best technical and medical construction of the apparatus, and the most thorough instruction of the technical and medical personnel. The knowledge of the therapeutic value of modern deep roentgen therapy will stimulate a systematic and correct investigation in order to avoid dangers, and thereby contribute more and more to the success of deep roentgen therapy.

FURTHER OBSERVATIONS ON THE RADIUM TREATMENT OF CANCER OF THE ESOPHAGUS WITH A REVIEW OF FORTY-FOUR CASES SO TREATED*

BY R. WALTER MILLS, M.D., AND JOHN B. KIMBROUGH, M.D.

ST. LOUIS, MISSOURI

THROUGH the kind invitation of your society it is our pleasure to address you on the subject of the "Radium Treatment of Cancer of the Esophagus" and to report the results of a series of 44 cases so treated. We previously presented case histories of the first 11 of these before the American Gastroenterological Association, in 1919, indicating results at that time, the published paper appearing in 1920. Since our present attitude is essentially that mentioned in the paper referred to, it seems perhaps best to review the position expressed at that time.

It was emphasized that cancer of the esophagus is one of the truly terrible diseases for which there is not even an adequate palliative treatment, to say nothing of a cure; and that it is an evident obligation to report the results of any treatment that offers a semblance of relief to the victims of the disease.

It was mentioned that cancer of the esophagus, aside from its unfortunate position and consequent security so far from successful surgical attack, is tantalizingly one of the most favorable of the internal carcinomas for treatment in that its symptoms are made manifest at a comparatively early stage by the resulting obstruction; that the type of cancer is usually epithelioid—amenable to radiation therapy; that carcinoma of the esophagus forms a naturally restricted tumor which will act as its own protective barrier; and that metastases occur probably later than in the instance of any other internal cancer.

Certain principles applicable to the use of radium generally, and common in cancer of the esophagus, were reviewed. These principles are familiar to all of you: the necessity for a knowledge of the exact location and physical peculiarities of the tumor; the necessity for as large a dose as can be tolerated with reasonable safety by normal tissue; the necessity for intimate contact of the radium with the tumor, and for a mechanical means of so emplacing it, maintaining it in position and permitting of ready withdrawal by an unskilled person in case of emergency.

SCHEMA OF CLASSIFICATION

Present Classification	Previous Classification
Cured.	
Palliative result good.....	Definitely successful palliative
Palliative result fairly good...	Successful palliative
Palliative result fair.....	Moderately successful palliative Fairly successful palliative
Palliative result fair only.....	Slightly palliative
Palliative result negative.....	Poor result

FIG. 1. Schema of classification of results of radium treatments. This classification has been very carefully adhered to, and every detail of each case reviewed and curves plotted, after the manner of those illustrating this article, to summarize the general results.

It was stated that roentgenoscopy and, in less measure, roentgenography afforded a unique means of aiding in the emplacement of the radium within the cancerous stricture, and of observation as to the permanency of such emplacement to a degree not equaled by esophagoscopy or approached by the old blind method. A method of emplacing radium under *x*-ray control was reviewed. The radium in a capsule of ordinary type with suitable filters of brass, German silver and rubber, was mounted on a rubber-covered wire of a certain texture and introduced after the manner of an ordinary esophageal sound, and when the terminal was favorably emplaced within the stricture the applicator was fixed in position by a head bandage and left *in situ* for a period of hours.

The results of the treatment of the 11 cases were summarized as palliatively good, without any case giving such evidence as would suggest that a cure had been effected.

It may be repeated that our present position after the additional 33 cases to be reported, is essentially the same; though it might be mentioned that one of the

* Read by invitation at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

TABLE I

RELATION OF SUCCESS OF TREATMENT TO DURATION THAT DISEASE EXISTED BEFORE TREATMENT

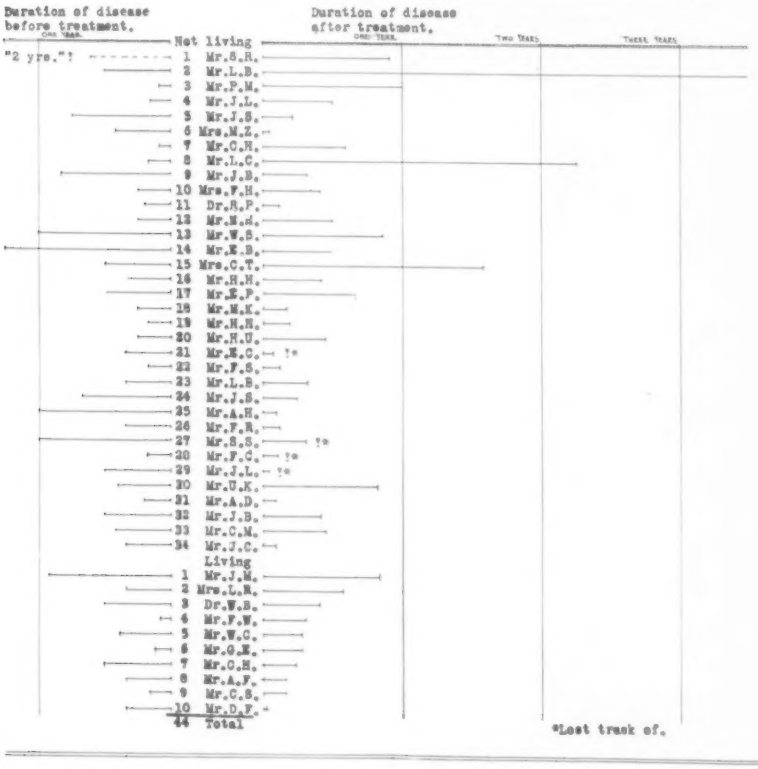

FIG. 2. Table illustrating success or failure of treatment as to longevity after radium treatment; also duration of disease before treatment, which curiously seems to bear little relation to the length of life thereafter. The very variable length of life after treatment probably reflects different histological nature of the lesion.

cases referred to in our first paper lived three and a half years, dying finally of pulmonary tuberculosis and exhaustion, and that an autopsy gave findings encouraging as to the future possibilities of the method. Moreover, with recent modifications of the technique, using stronger dosage, palliative results have been better.

It seems probable that the radium treatment of cancer of the esophagus is destined to be supplemented, though hardly replaced, by modern massive high-voltage *x*-ray therapy. During the past few weeks we have been treating all cases under observation with this method in addition to the use of radium. The results so far have not been striking. It would seem that the present series, with the exception of these few latter cases, having been treated by radium alone, will have future value in that it affords a criterion as to the result of radium therapy probably not possible in the future on account of the obligation to use *x*-ray therapy as a supplement.

TABLE II

GENERAL RESULTS OF RADIUM TREATMENT

Cured*	0
Palliative result good	12
Palliative result fairly good	12
Palliative result fair	14
Palliative result fair only	3
Palliative result negative	3
Total	44

* Ten cases still under observation, including the most favorable ones treated by recent, more vigorous methods.

FIG. 3. A statistical table showing results of treatment as noted according to schema shown in Figure 1. It may be observed that in much the larger proportion of cases the treatment was noted as palliatively good to fairly good. The method of radium treatment of carcinoma of esophagus may on the whole be considered a successful palliative procedure. We are inclined to rate it a definite advance over gastrostomy as a palliative measure.

The diagnosis was established by clinical methods and the *x*-ray, supplemented in a few cases by esophagoscopy. It is doubtful whether there were any errors as suggested by the subsequent course of the disease—amenableness to radium therapy, all too few autopsies and occasionally operation when gastrostomy had to be performed and where the lesion demonstrably involved the abdominal esophagus.

The possibility of metastases being present was not taken into consideration and no particular diagnostic search was made for them, because their detection would not contraindicate the use of a method as yet essentially palliative, and consequently indicated whether secondary growths were present or not. It is unique that metastases seem to occur late in carcinoma of the esophagus. In the two of our cases that lived the longest, there were no secondary growths found on complete autopsy.

Naturally one of your chief interests will center on the question of technique. This may be divided, first, into matter that pertains to the method of application and secondly, dosage. The technique of application is not easy, a matter of careful detail and difficult to express in words. The applicator used is simple, almost crude, and consists of an ordinary brass radium-bearing terminal mounted on a heavy, square, drawn silver wire having a considerable alloy; stiff enough to hold any angle at which it may be found necessary to deflect the terminal in order to canalize a given stricture, and not twist when rotated in the esophagus. It should not be so stiff that it will not readily take the upper pharyngeal and mouth curves, and so cause irritation. Over the wire is drawn a rubber tube of rather heavy wall and fine lumen, so that it may snugly fit the wire carrier, and of the same external diameter as that of the terminal container. Over the radium-containing capsule with its filters is drawn and cemented a rubber stall, the kind used being a portion of a fountain-pen bladder. Others have written of more elaborate apparatus, but the one described is designed primarily to be utilized under *x*-ray control and has been especially planned to effect accurate canalization of the carcinomatous stricture, and maintain such position. It also has the advantage of easy withdrawal by a nurse or other attendant in case the patient gets into difficulty. It is somewhat trying to the patient, though very few of our cases

TABLE III

STATISTICAL TABLE OF INCIDENCE, LOCATION, AND CONDITION OF LESION

		R	B	M	L	S	Z	H	C	B	H	P	H	S	B	T	H	P	K	H	U	C	S	B	S	H	R	S	C	L	K	D	M	B	R	M	B	W	C	E	H	C	F	S	F	TOTALS
SEX	Male	•	•	•	•	•		•	•	•		•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•		40
	Female						•				•					•																			•												4
AGE INCIDENCE	4th decade	•									•	•							•						•				•		•										•		•	•		10
	5th decade		•	•		•				•			•	•		•		•				•	•			•	•		•		•		•	•		•				•					19
	6th decade						•	•	•								•			•				•												•		•						•	•	11
	7th decade				•											•					•																								3
	8th decade																											•																		1
LOCATION OF LESION	Upper 1/3																•	•				•	•					•		•				•	•					•	•				10
	Middle 1/3							•		•				•																		•											•	•	•	•	8
	Lower 1/3		•	•	•		•				•		•						•	•				•	•			•	•				•						•						15
	Abdominal	•				•			•			•			•	•				•						•								•					•							11
STAGE OF LESION	Advanced					•							•	•															•		•										•	•				7
	Moderately advanced	•	•		•		•	•		•	•						•	•			•				•	•			•																13
	Somewhat advanced														•				•		•		•		•								•	•		•						•		•	11
	Fairly early			•					•			•																							•											7
	Early															•				•			•																				•		•		6
DEGREE OF OBSTRUCTION	Totally obstructed												•	•																																2
	Markedly obstructed	•			•		•	•										•													•											•	•			8
	Moderately obstructed		•	•		•					•	•								•	•							•								•		•	•				•	•	•	15
	Slightly obstructed								•	•					•	•	•		•	•		•	•	•	•				•		•	•	•	•			•			•						19
	Non obstructed																																														

FIG. 4. A self-explanatory statistical table indicating incidence as to sex, age, location of lesion, stage of advance, and degree of obstruction. It is interesting that the great preponderance of cases occur in males, chiefly in the fifth decade, and in somewhat less measure the fourth and sixth, that all portions of the esophagus are nearly equally affected, that most cases presenting themselves for treatment are but moderately early, that the larger percentage of cases are moderately obstructive, and that total obstruction is not common.

have failed to tolerate it. It has had to be withdrawn but 8 times in 125 applications.

A preliminary hypodermic of a quarter of a grain of morphine is given at least a half-hour before the treatment is begun. This is of the greatest importance, and to a large degree makes the whole procedure possible. In case the patient becomes restless or nervous during the treatment, a second smaller dose may be necessary.

Before the applicator is introduced, it is of the greatest importance to have an entire familiarity with the individual lesion through previous screen and plate studies. The stricture should be observed in both right and left lateral poses with

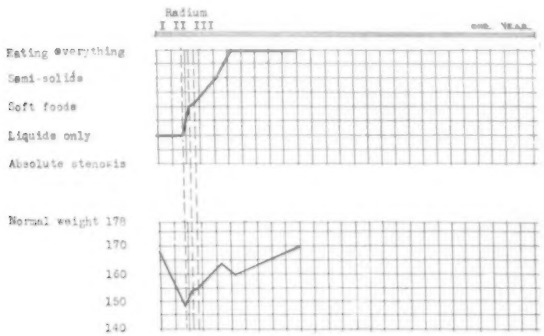

FIG. 5. A plotted curve graphically illustrating the result of radium treatment in carcinoma of the esophagus. In this case, though under observation but a short time, the palliative result has been strikingly good. The man eats everything and has returned to work. At present (July 26, 1922) the same good condition obtains six and a half months after the initial radium treatment. The patient is working and in the best of health. It took a week to learn to canalize this stricture in the abdominal esophagus. The patient was apparently within weeks of death from starvation and general depression. The case illustrates the more recent method of using three radium treatments in rapid succession: i.e., at intervals of three days, which we have learned to regard as the most effective procedure. The final palliative result is rated as good. It is conceivable that it may result in a cure.

the patient standing, and its direction in each determined, thus enabling one to form a mental picture of its direction in two 90-degree planes. Just a second before the introduction of the applicator the patient is given a mouthful of a barium mixture; either a water mixture or a stiffer medium according to the degree of obstruction, so that the stricture may be made fluoroscopically apparent during its canal-

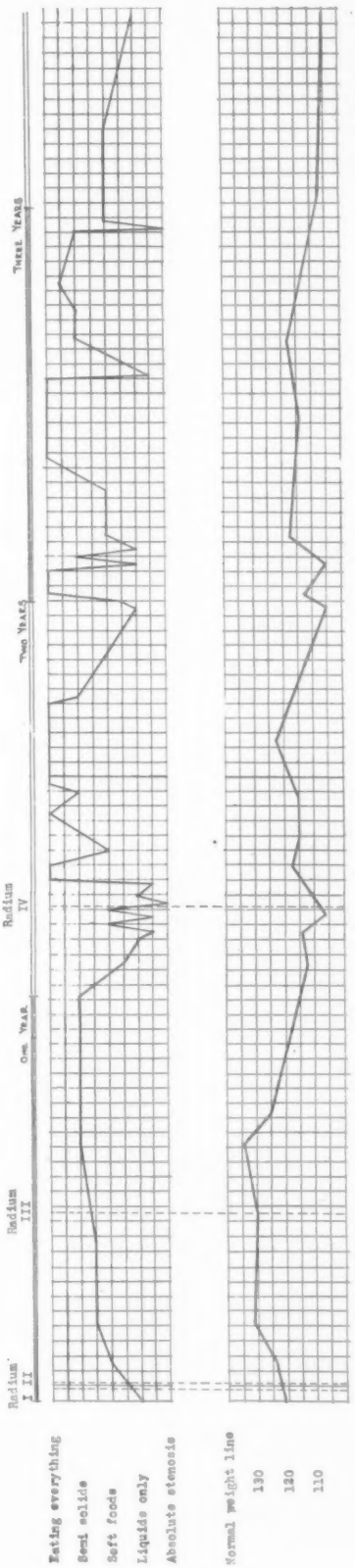

FIG. 6 Graphic curve illustrating the results of radium treatment in a case which lived three and a half years after the initial treatment. Death finally from pulmonary tuberculosis (autopsy). Lesion in abdominal esophagus, a mass of sclerotic tissue, had extended downward until it formed a carcinomatous collar about the cardia. It could possibly have been controlled there by radium treatments, had it been diagnosed in life. The immediate effect of each radium treatment is shown by the course of the curve. The final result is rated as palliatively good.

ization by the radium terminal. In case the stricture is but slight and non-retentive, additional barium mixture may be fed by a spoon alongside the applicator, though this is not always successful. Another procedure in cases where there is but slight obstruction, is to mark on the skin of the body the proximal and distal levels of the stricture with the patient in a very carefully noted diagonal pose. The correct position of the applicator in the stricture will correspond to these marks when the patient is in exactly the same pose as controlled ortho-fluoroscopically.

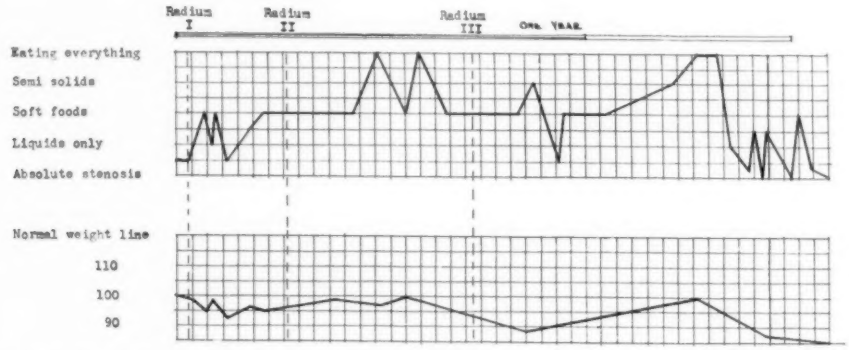

FIG. 7. A curve graphically illustrating the course of a case treated by radium after the original method, i.e., using radium on the recurrence of symptoms. Patient lived one year and seven months, dying finally of inanition resulting probably largely from secondary contracture. The final result is rated as palliatively fairly good.

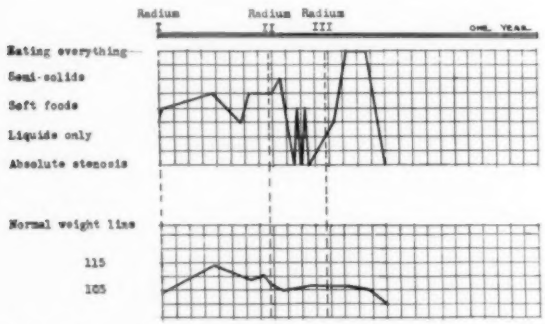

FIG. 8. A graphic record indicating the course of a case after radium treatment. The patient lived seven months after the initial treatment. The result is classified as but palliatively fairly good.

The feel of the applicator canalizing the stricture is of help. In the great majority of instances such procedure will not be necessary, as the stricture usually contains a sufficient thread of barium which, together with some retained in the proximal dilated esophagus above, will identify it.

The applicator is prepared for introduction by carefully straightening the shaft and deflecting the terminal at an angle corresponding to that of the stricture in relation to the longitudinal axis of the esophagus above. The end of the applicator that is to extend out of the mouth is bent into a circular form whose plane will be exactly in that of the deflected radium terminal, so that it may give information as to the direction of the latter after the applicator is within the esophagus. In making the introduction the patient sits on a rather low stool, the operator standing behind him. The applicator is introduced

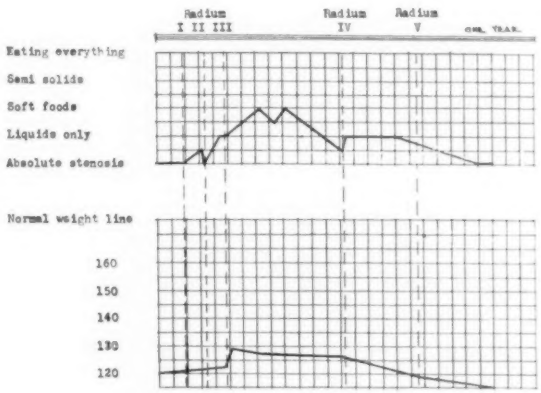

FIG. 9. A curve showing the results of radium treatment in a case in which the result is classified as palliatively fair. Case totally obstructed when first seen; a stretcher case. Esophagus opened by radium treatment so that the patient was able to eat soft food. The curve is influenced by the fact that a gastrostomy had to be done before the patient developed sufficient strength to undergo the radium treatment.

after the manner of an ordinary esophageal bougie, great care being taken to see that the patient's head is kept always back so that the esophagus and pharynx are as nearly in a straight line as possible, and to avoid bending the shaft of the applicator which would make a successful rotation of the terminal impossible. One of the greatest difficulties is to pass the pharyngeal esophagus with the radium-bearing terminal of the applicator deflected at as marked an angle as is often necessary, especially the case when the lesion is in the abdominal esophagus. Various tricks are of use almost impossible to describe. After the applicator has reached the lowest levels of the dilated esophagus, the patient is made to stand, carefully keeping the head extended, and is guided behind the fluoroscopic screen. When properly placed, usually in the right lateral pose, an effort is made to canalize the stricture by manipulating the portion of the applicator projecting from the mouth, at the same time observing the procedure fluoroscopically, the circle-like form into which this portion was bent before the introduction, aiding greatly. If the terminal does not immediately engage the stricture, which is usually the case, the applicator may be rotated outside the mouth until it is tricked or jumped into the opening of the stricture, keeping in mind the essential individual two-planed plan of that particular stricture. The fluoroscope gives a vivid idea of how easy it would be to perforate the esophagus, were the terminal not exactly engaged in the stricture and external pressure exerted. An anteroposterior view, or a left lateral rotation of the patient, is helpful. The whole procedure is somewhat after the manner of the catheterization of the Eustachian tube, though with the advantage of being visible and the disadvantage that the procedure will never be the same in any two cases. When the applicator is in place, it is fixed in position by a narrow bandage arranged in bridle fashion about the patient's head and neck. After it is thus fixed in position, the patient with head extended, is led to another room where a suitable reclining-chair with headrest has been prepared for him to sit in during the period of treatment. The headrest is arranged so that the head is kept always extended; this on account of the danger of injury through movements of the head, and that the shaft may be kept in an approximately straight line, so that further manipulations during the course of the treatment are possible if they become necessary. The position of the terminal can be checked fluoroscopically a few times during the treatment. In instances of a lengthy stricture the bridle bandage can be readjusted so that the terminal will extend slightly lower into the stricture for the second half of the treatment, in order to irradiate all portions

FIG. 10. Above, the applicator as ready for use, the wire shaft covered with rubber tubing, rubber stall cemented over terminal. The terminal is shown bent at an obtuse angle as though for the canalization of a given carcinomatous stricture in which exactly such deflection is necessary.

Below, the metal terminal and wire carrier. The proximal portion of the applicator is shown bent in spiral form as ready for use. The plane of such spiral, being in exactly that of the deflected terminal, indicates its direction when in the esophagus.

of it. At the end of the six-hour period the applicator is withdrawn after a final fluoroscopic observation as to its position. The presence of any blood on it should be noted.

A careful and detailed record is kept of every stage of the application, and a final note made as to the exact technique that was successful in that particular case; especially a description of the different directions and rotations necessary to canalize the stricture. Often a tracing of the deflection of the terminal and sketches are helpful. In our series in no case did we fail to canalize the stricture, though in

certain instances it has taken efforts on several successive days, and as long as a week to accomplish this finally, through gradually accumulated experience with that particular case. In no instance was injury done. One must pause to imagine what doubtless happened in the old days of blind esophageal instrumentation; we doubt not that many a perforation occurred which was not reported in the literature. The earliest case of carcinoma of the esophagus that we have ever seen, as shown by autopsy, was perforated by a practitioner with an ordinary bougie.

Modifications of the technique may be necessary to suit the individual case. Thus, at times the stricture is so narrow that certain filters must be omitted to effect canalization. In certain instances the applicator must be mounted in a small colon tube or large catheter to effect the canalization of the abdominal esophagus on account of its abrupt curve. If this is necessary, it is best to anchor the radium 1 in. from the tip of the tube, the tip acting as a guide. In 2 cases the carcinomatous stricture was canalized when there had been absolute obstruction for more than a week. This was effected by finding a sort of cleavage point and gradually working the terminal into it. In certain strictures, only the proximal portion can at first be canalized, but it has been found that if the radium be left so emplaced, in a few hours, it will gradually work deeper, either as a result of gentle pressure by the terminal or shrinkage through the action of the radium; perhaps both.

FIG. 11. Showing a characteristic carcinoma of the very lower thoracic and abdominal esophagus, a common form, difficult of canalization on account of the degree of angulation of the thoracic esophagus. Compare with the following illustration indicating the method of canalization by the deflected radium terminal.

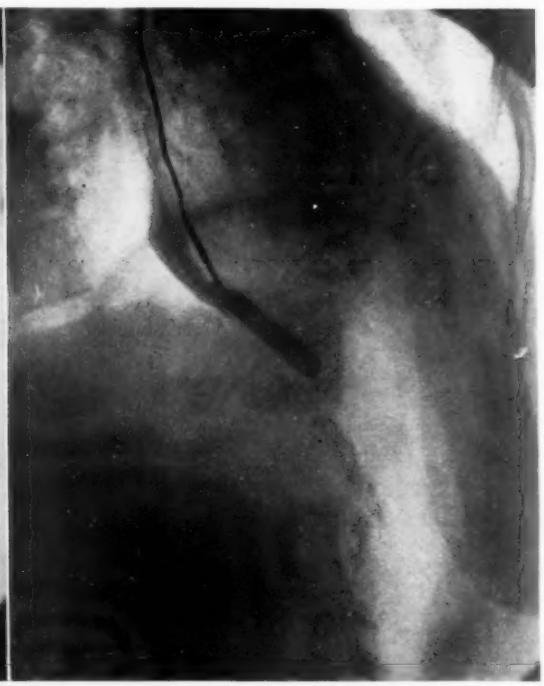

FIG. 12. Showing the marked deflection of the radium terminal necessary to canalize a given carcinomatous stricture of the abdominal esophagus. Compare with the preceding figure.

In all probability the means described can be improved upon, but it has been found reasonably effective, and is the product of actual experience.

TECHNIQUE OF DOSAGE

It is obvious that certain principles as to dosage are applicable in carcinoma of the esophagus. It is equally obvious that there are restrictions as to the means and manner of irradiation on account of the

position and physical peculiarities of the tumor. It is evident that distance filtration is not possible, and that intimacy of contact is possible. Peripheral secondary supportive irradiation is impossible; the tumor can be irradiated only centrally. Radiation by emanation needles is hardly feasible, though it might be attempted under esophagoscopic control, and is not appropriate on account of the danger of perforation and deep slough with the resulting possibility of secondary perforation. On the other hand, a certain amount of superficial slough within the lumen of the esophagus may be of benefit, through affording relief of the obstruction.

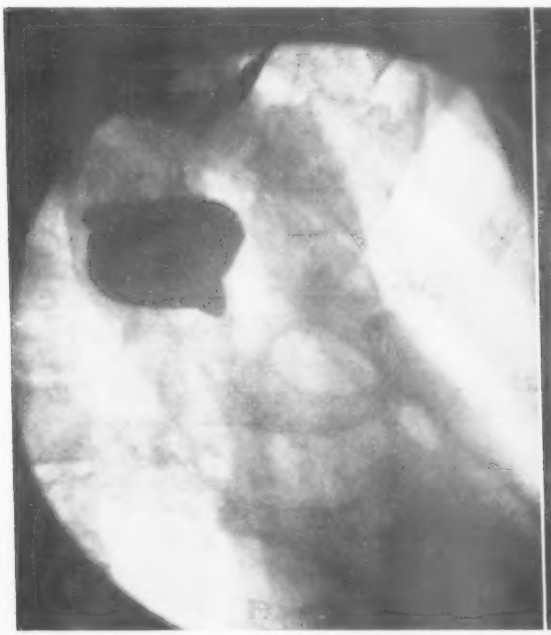

FIG. 13. Illustrating stasis proximal to a totally obstructive carcinoma of the esophagus. Plate two days after initial barium ingestion. Stretcher case. Patient unable to swallow even water for one week previous to initial observation. Compare with two following figures which show the method of canalization of such a lesion (Fig. 14) and the result (Fig. 15).

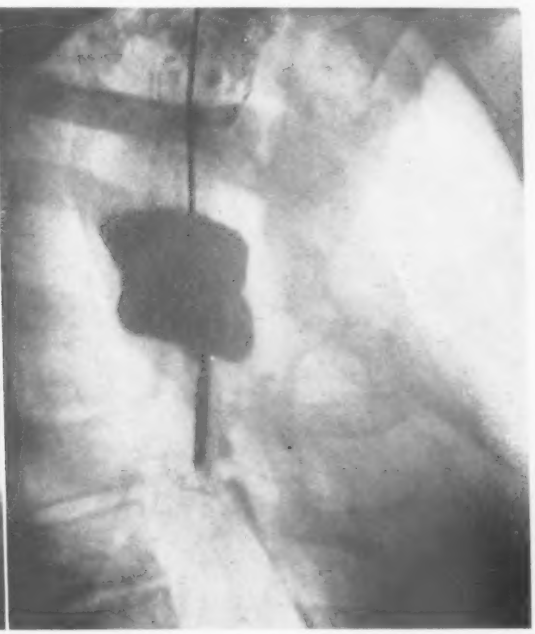

FIG. 14. The canalization of a previously totally obstructive carcinomatous stricture of the esophagus. (See preceding figure.) The illustration was made during the third radium treatment after the total obstructive stricture had become patent to a slight degree. The danger of the blind method without control by the *x*-ray is suggested, as it will be noted that the radium terminal is not in the axis of the esophagus, and a perforation might occur. In this instance the terminal was driven into a totally obstructing carcinomatous mass after finding a sort of line of cleavage, with the result that the total obstruction was relieved. (See following figure.)

DOSE

The dose should be as large as can be tolerated by normally local tissue with fair safety. It should be applied to all portions of the tumor, but maximally to those portions that are probably or can be actually determined by *x*-ray plates as the result of the pressure and the adjustment of the applicator to the esophageal curves, or perhaps through actual shrinkage of tissue due to the action of the radium. During the latter stages of the treatment it may be necessary to elevate again the terminal to the upper reaches of the stricture.

As to the dosage itself, we have taken the position that it was best to use a dose well within the bounds of safety; and the majority of our cases have, with this idea, been treated with a dose that we must now regard as not only entirely safe, but as inadequate to the demands of the situation. Consequently of late we have been treating cases with a considerably heavier dosage. The smaller original dose was 50 mgm. of radium element left *in situ* for six hrs.—300 mgm. hrs. Our later plan has been to use the same dose but repeat

FIG. 15. Formerly totally obstructive stricture of the esophagus opened by radium treatment in definite degree. Plate, taken three days after third treatment, shows definite canalization by barium. Patient able to take soft foods and resume work for a time as salesman in a furniture store. (See two preceding figures.)

it every third day for three times, totaling 900 mgm. hrs. We have considered these three successive applications as amounting to a single dose as they occur well within the period of cellular reactive change. Since results have been rather strikingly better since using this larger dose, and especially since no untoward results have occurred, we feel that a still larger dose may be attempted in the future, and anticipate using next, 1,200 mgm. hrs.; in our opinion probably a safe procedure with the same filtration as that used in all treatments, namely, ½ mm. of German silver, 1 mm. of brass and a thickness of rubber. We also anticipate that in certain more extensive tumors a larger amount of radium, probably 75 mgm. can be used to advantage, on account of the fact that it is doubtful whether the smaller dose effectively irradiates the entire lesion. It has the considerable disadvantage of being more bulky.

Our original plan was to treat initially with the dose mentioned, 300 mgm. hrs., repeating this on the recurrence of unfavorable symptoms, if necessary a number of times. Feeling that there is just a

Radium Treatment No. 2

9 a.m.	Hypodermic injection of ¼ gr. of morphine and 1/150 gr. of atropine.
10 a.m.	Introduction of 50 mg. of radium mounted on ordinary applicator, filtered with rubber, brass, and silver. Introduction most difficult, i.e., difficult to pass pharynx with adequate angulation, and more difficult to canalize full depth of stricture. *Technical.* Terminal deflected rather markedly in one plane and slightly laterally in right angle plane (90°). Need really more angulation than was possible on account of double right angulated course of lower stricture (seen with patient in left lateral position). Radium left nearly imbedded in upper half of stricture but not canalizing "double angle" (did canalize at initial treatment). *See Sketch.*
11 a.m.	Radium as last emplaced.
2 p.m.	Radium slightly higher than as last emplaced. Replaced slightly lower level in "false pocket."
4 p.m.	As last emplaced. Removed. No blood. Patient in good shape.

FIG. 16. Page from detailed notes showing method of recording data pertaining to radium treatments with special reference to the technique necessary in the individual case. (See two succeeding illustrations.)

possibility of developing a radical cure of the disease, given early diagnosis, and hoping thus to prevent secondary sclerosis with late contractural stenosis, we have concluded that the treatment must be as maximally massive as safety will permit. To repeat; as far as we have tried heavier dosage, the results are distinctly more palliatively favorable than with the smaller dose.

CONCLUSIONS

We may state our conclusions as to the results of the treatment of the cases reported. Rather elaborate notes have

been kept and an effort made to keep in touch with all patients, noting the general outcome and clinical course of the disease. But 4 patients were lost track of.

It is difficult to form an estimate as to the benefit of the treatment because of different initial conditions. No case was refused treatment. Most of the cases were lamentably late, some were totally obstructed, some gastrostomized, some stretcher cases, and pitifully none were what could be considered very early. Apropos we might make a hard arraignment of those who first see these cases, give medicine, temporize, and hope until the condition becomes advanced, without attempting to make a diagnosis. A still more depressing view is that many, even most of the patients themselves, being nervously sound and usually in good health otherwise, do not seek aid for sometime after the onset of difficulty in swallowing certain foods, and until they have attempted various home methods of relief. In order to diagnose these cases early, and thus afford them better help, an educational propaganda is needed after the fashion of that conducted in the instances of pulmonary tuberculosis, cancer of the breast, uterus and so on, but more difficult because of the comparative rarity of the disease.

As previously stated we have seen no case that would indicate that a cure had been effected, nor do we believe that in our series any case will probably result in a cure. This in itself is naturally discouraging. On the other hand it may be emphasized that we have made but a beginning. As in *x*-ray therapy, certain discouraging phases must be passed through. We are at present accumulating knowledge and experience on which we may modify, reconstruct and build our methods of the future. It is encouraging that cancer of the esophagus shows a definite amenability to a degree to radium therapy. The principles are obvious. Even in our small series, and with but a very restricted variation as to dose, we have obtained much better palliative results

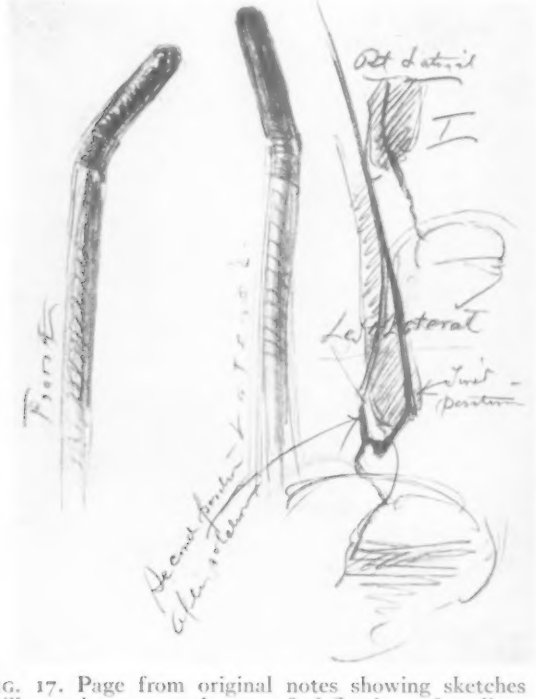

FIG. 17. Page from original notes showing sketches illustrating exact degree of deflection of radium terminal and manner of manipulation necessary to canalize the stricture in a given case. (See preceding figure, same case.)

FIG. 18. Page from original notes. Sketch made from tracing of applicator showing exact degree of deflection of terminal and shaft necessary to canalize a given stricture. Such information thus readily available for future treatments. (See two preceding illustrations, same case.)

of late than we did at first, and we now anticipate good palliative results with a considerable degree of confidence. We must regard the treatment as a successful palliative measure. It unquestionably prolongs life and lessens the agony of starvation and thirst.

In our series of 44 cases, the palliative result was strikingly good in 12; in an additional 12, it may be summarized as fairly good; in 14, fair; in 3, fair only, and in 3 others it was considered negative. Thirty-four cases have died; 10 are still living and under observation. The length of life after treatment varies exceedingly, in general, in proportion to the stage and severity of the disease. It seems possible also that it may vary according to the histological character of the lesion. Curiously, there seems little relation between the time that the disease had existed before treatment and the length of life thereafter. This is probably only apparent and indicates the period during which the symptom-provoking obstruction has existed. The longest duration of life after treatment was three and a half years. In this instance an autopsy indicated that death was not due to the lesion directly. The original site of the carcinoma in the lower thoracic esophagus was a mass of scar tissue in which were caught carcinomatous cells. The disease had extended down the abdominal esophagus and formed a small cancerous collar about the cardia. It could possibly have been controlled here, had this been determined to have been the case during life. Most interestingly the lesion was histologically an epithelioma, common in the esophagus but exceedingly rare in the stomach, especially the fundus of the stomach, and thus strongly suggesting that there had been an extension from an original esophageal lesion. Another case lived two years and four months; another, a year and seven months; the remainder of those not living died within

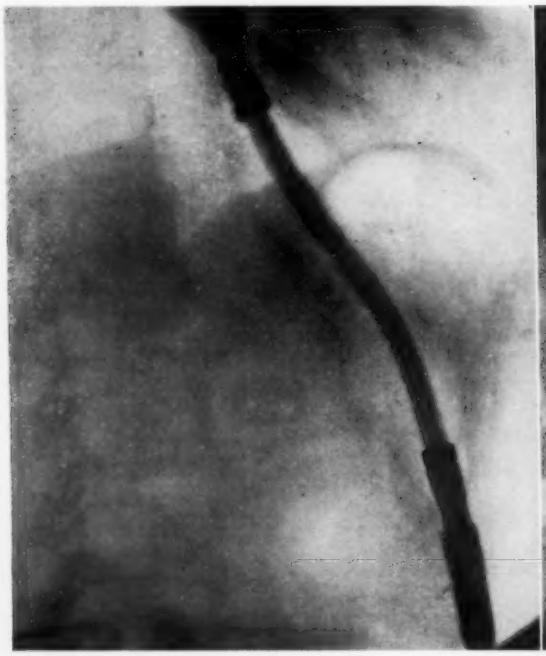

FIG. 19. A specially constructed cardiospasm dilator *in situ* divulsing a "cardiospasm." Illustration to show that the method of x-ray control is very applicable in other esophageal instrumentations. The dilator contains bismuth in the tip and is provided with lead ring markers. The divulsion of cardiospasm by such an apparatus is a revelation as to what occurs and what must not have occurred by the old blind method. It has been found that the divulsing balloon is best used smaller than as in the older dilators. (See following figure.)

FIG. 20. To illustrate another outlet for x-ray control of esophageal instrumentation. The divulsion by a bougie of a stricture of the esophagus, here probably largely the result of the radium treatment of a carcinoma, by an ordinary silk gutta-percha bougie loaded with bismuth.

a year. When one recalls that cancer of the esophagus kills with almost unprecedented rapidity it cannot but be considered that the treatment lengthened life appreciably. In all but 3 cases there was relief of dysphagia—in certain of these very striking. Patients scarcely able to take water, and that not in adequate amounts, were able, after treatment to take a liberal soft diet; and in certain recent more heavily treated cases the patients can eat everything, including such foods as cabbage and dried herring. Of these latter favorable cases, a few regained nearly former weight, returned to work and are still working. One man who was within weeks of death three months ago is walking twelve miles a day as an inspector.

The treatment has resulted as is often the case in similar endeavors, in the development of unforeseen difficulties. Thus the problem of secondary sclerotic stenosis, that must be dealt with as a benign stricture requiring bouginage, is a real difficulty.

The occurrence of pain, thoracic in general, or of curious reflection to pectoral or other regions, even the jaws and teeth, is an unfortunate secondary development that we have learned to regard as an ill-omen, and probably indicates the peripheral extension of the lesion with involvement of nerve tracts. This pain has a most unfavorable influence in lowering the general condition and morale of the patient. Ordinarily such pain is not seen in cancer of the esophagus, because patients do not live long enough to develop it. Secondary intermittent spasm at the site of the stenosing stricture caused much distress in certain cases.

DISCUSSION

Dr. Kimbrough. There are only one or two points to which I wish to call attention. First, every patient has received immediate relief. I do not think the immediate relief was entirely due to the radium, but partly to the effect of the bougie and instrumentation, although I do think that the radium has enabled the structure to remain open. The first essential in these cases is to know the location and extent of the tumors. The next is the dosage. From the specimen we were fortunate enough to obtain after the post-mortem, we found the entire tumor growth had been destroyed. Now if that is true, we can hope for better results if we can use enough radium to destroy the entire cancer growth. All the patients have been benefited, but the statistics show that only 10 are alive. Our results, therefore, have only been palliative. How can we improve these? I believe we will get better results by increasing the dosage. We were giving 50 mgm. for six hrs., and repeating this in six weeks. I think a larger dose, say 75 mgm. repeated every three days until they have three or four doses, would give better results.

Dr. Quigley. Within the last few years, we have found out a good deal about cancer of the esophagus, because we have given it more attention. It was formerly considered incurable, and not much attention was paid to it. Cancer of the esophagus constitutes about 9 per cent of the cancer deaths in America, England and Wales, and other countries from which we get statistics. Any disease with such a large percentage of deaths should be of great interest.

Another thing of interest is that on post-mortem, we find in these cases of cancer of the esophagus, that the patients nearly always succumb because of a mechanical effect. The patient starves to death because the esophagus is shut off. The small percentage, about 5 per cent, that are of the glandular type, are untreatable and incurable. We do not need to consider them. Those grave ones start at the bifurcation or at the cardia opening, and they usually remain for a long time localized in one particular spot. They do not metastasize early, so if radium is applied early in the disease and applied properly, these things should be curable, and I hope to see in the future that they are.

One other point that I wish to call to your attention, which I consider of great importance, is this: In looking up the registration statistics, in the United States, England and Wales, we find one symptom outstanding in the making of early diagnoses in these cases, and this one symptom is usually overlooked by the doctor to whom the patient goes for relief. That is, the difficulty in swallowing. Patients complain of pain and of coughing up blood, but in the early stage they complain of the dysphagia, or difficulty in swallowing. If we investigate with the *x*-ray everything of this nature that comes to the office of the general practitioner we will get a lot of these cases early enough and localized enough so that we can get many more cures.

We use the Sippy instrument in treatment of these cases. We dilate them first by a 44 or 48 bougie, and then, after we dilate them, we put the radium tube at the shoulder of the largest bougie, then introduce the Sippy bougies down along the piano wire so that when withdrawn a

short distance, we have the radium tube right in the narrow space. We have had good results in treating these growths in this way.

Dr. Stone. I think the doctor is to be congratulated on the efforts he has made. I have observed the work which was begun by Dr. Janeway and followed recently by Dr. Quick, and the results have so far been discouraging. The difficulty of getting these cases early appears to depend upon the peculiar anatomy of the esophagus. The mucosa is extremely thin and delicate, and the growth, instead of spreading by direct continuity of mucous membrane, penetrates deeply, and then spreads beneath the mucosa, so that often another lesion may appear several inches away from the original site. I am afraid that most of the immediate results that have been obtained have been due to the stretching of the growth during the manipulation of the treatment. Primary perforation from this manipulation may be prevented, but subsequent perforation may result from the necrosis which the radium has produced—occurring sometimes five or six weeks after treatment has been applied.

Dr. Hanford. I was much interested in the technique given by the essayist. I have eliminated the introduction of the metal guide. It is continuously irritating, and the patient is continually gagging. There was a time when I employed whalebone to introduce radium to the site of the lesion. Also soft silver wires had their day, but they were very distressing to the patient and have been discontinued. I also use the piano wire, to commence the dilation. In the first step I have the patient swallow silk twist, letter D or E. This should be anchored in the intestine in twenty-four hrs., and will act as guide for the piano wire as well as the radium carrier. It is understood that the stricture has been located before dilation is attempted. The silk twist is now threaded through the cone-shaped end on the piano wire and the latter is passed down the silk thread till the end is in the stomach. At this point the olivary bodies are threaded on to the piano wire until the patient is able to take a No. 41. These are pushed down through the stricture, after which the piano wire, together with the olivary bodies, is removed. The string is still retained as the guide for the carrier. My carrier is very simple. It consists of a metal barrel (brass) 3 cm. long, 8 mm. outside diameter, 1 mm. wall thickness. On the distal end is a cone-shaped body about 1 cm. long, and on the end of this is a hollow spiral wire 7 cm. long. There is an opening on the side of this spiral wire near where it joins the main portion of the carrier. The silk twist, which is acting as our guide, is threaded through this spiral wire. On the proximal end of the barrel of the carrier is a screw cap, in the head of which is a hole where the end of my spiral wire pusher loosely fits. There is also a small hole through this cap where the heavy silk cord is threaded, by which the carrier is removed after irradiation. In introducing, the assistant holds the silk twist guide taut, and the carrier is made to slide down the twist by means of the pusher. The heavy removal cord is held tight, so that the pusher will not be dislodged, in its passage down. The patient is all this time behind the fluoroscope. When the barrel of the carrier is at the point of stricture, which has already been located by a coin on the chest wall, when the patient was swallowing the bismuth, the pusher is removed, leaving the carrier in position. The removal cord is fastened to the cheek by adhesive tape. If there is any fear that the patient may bite through the string, the latter can be fastened to a tooth. Two mm. wall thickness rubber tubing is slipped over the barrel, to absorb the secondary rays. The carrier may remain in position for twenty-four hrs. without discomfort to the patient.

My dosage is larger than when I gave my preliminary report, and by this increase I find our results are better. I now give 600 to 800 mgm. hrs at the first application, and repeat this in a week, after which the patient rests for three weeks.

In closing, I wish to relate that one case that gave a perfect picture of carcinoma of the esophagus, and was benefited by radium, showed, at necropsy, tuberculosis, but no carcinoma.

Dr. Mills (closing discussion). Most of the points that were mentioned in the discussion we tried to review in the paper. Dr. Quigley stated that carcinoma of the esophagus accounted for 9 per cent of all cancer deaths. This is surprising to me, when we recall the cancer incidence in other organs. I had always regarded cancer of the esophagus as rather rare. With reference to the method of esophagoscopic control versus the fluoroscope; it would be very difficult for me to accept any sort of method of blind instrumentation. I used the Sippy method of stricture instrumentation before we used the *x*-ray as a means of control, and I cannot help feeling that the method that affords the opportunity to see what one is doing has a marked advantage over the other in which one does not. The use of the wire radium applicator in the throat is difficult but with the aid of morphine many of these patients have little distress and often slumber through the treatment. At any rate they are not a class of patients who are very particular when they are starving and see a chance for relief. They

will submit to anything. Again, if a method jeopardizes accuracy of getting into the stricture, or any portion of it, I must select another that does not.

In our series of cases only one perforated at a time and in a way that suggested that this might have been the result of the radium treatment. Others perforated late, some weeks or months after the treatment; in one case two months, but not at such a time as would lead to the conjecture that it was other than incidental.

THE TREATMENT OF SUPERFICIAL CANCER, WITH STATISTICS AND TECHNIQUE*

BY D. T. QUIGLEY, M.D., F.A.C.S.

OMAHA, NEBRASKA

THE cases recorded here number 593. This number we have been able to trace over periods of from two to seven years. In this group we have included cases of cancer of basal-cell, gland-cell and squamous-cell type, and also the melanotic tumors—the so-called melanosarcomata, which are really melano-epitheliomata.

The superficial type of malignancy was chosen for this paper because this type is the most easily treated and studied, and in the matter of treatment, if we have anything of real value to offer, it should show at its best here. Another consideration is that if we have a remedy that really works well in superficial, localized cancer, then we are close to having the key to the whole situation, because every cancer passes through a stage when it is localized, and nearly every localized cancer can, by proper surgical methods, be made superficial or accessible.

Of face cases in this group, we have had 146, and of these, six were of the melanotic type, growing from moles and showing evidences of malignancy in rapid growth or ulceration. Some of these were quite large, one being 1½ in. in diameter, and another, having been scattered by several operations, was irregularly distributed over an area about 2 in. square. All of these melanotic cases were cured. Of the basal-cell and squamous-cell varieties, about ten per cent failed to heal. Among the failures, some were in patients of low vitality, and some in patients in whom the disease was so extensive that the treatment was undertaken without hope of cure, but to afford temporary relief. In the cases that at once healed completely, recurrences were very few. For such recurrence, five per cent were subjected to second applications, and about two per cent of the cured cases were subjected to a third treatment.

Of lip cancer, we have had 171 cases. Many enlarged glands, or considerable growth in few glands, means death for the patient in practically every case, but localization of the growth just as surely means cure if the patient is properly treated. Lip cancer remains local for a much longer time than we have been led to believe. Of our lip group we have had 19 or about 10 per cent of failures to heal.

Cancer of the eyelids presents a particularly interesting group because these cases do not, for anatomical reasons, lend themselves readily to operation, and if they are operated on, they almost surely recur. The patient then finds himself with a larger and deeper epithelioma, and whether or not another operation is done, the disease eventually gets into the orbit, destroys the eye, and later destroys the patient's life. In the eyelid group we have had 99 cases. Of these, 2 were melanotic, and one was sarcoma of the upper lid. In this group we had 7 which failed to heal and one accidental burn of the cornea which did not heal.

Of cases involving the skin of the nose, we had 116, and of these, one was skin sarcoma and 2 were melanotic. These 3 cases healed promptly. Of the remainder, we had 7 which were not cured. Most of the nose cases were small epitheliomata, but a few covered quite a large surface area. We did not get complete or permanent healing in any nose case which invaded bone or cartilage.

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

Our ear cases are 22 in number, and of these, 5 failed to heal. The malignant disease invades the cartilage very early, and this tissue does not heal well. In some of the cases that involved cartilage, plastic work was necessary to remove the diseased edges of cartilage and cover with skin.

Of hand cases, we have had 14, of which 4 failed to heal. Malignancy on the back of the hand is prone to form metastasis early, as the area is massaged with every movement of the hand and it is exposed to light and trauma. The cases in which we failed were those in which the disease covered a large area, or in which metastasis had already developed in the axilla. One such case, in which we removed the arm and glands after a preliminary raying, is well after five years.

We have had 4 epitheliomas on the back that were severe enough to be dignified with the term malignant. Of these, 3 were melanotic and one squamous-cell. Two of the melanotic died. The other, which was small, and the squamous-cell epithelioma were cured.

Of scalp cases, we had 7, 3 of which were failures.

Of penis cases, we had 3. One died, and two had amputations following radium treatment. The two latter cases are apparently well.

Of Paget's disease of the nipple, we had 6 cases, of which 2 are dead and 4 apparently cured.

Of epithelioma of the navel, we have had 2 cases, and both are dead.

Of cases involving the fingers, we have had 3 cases, 2 of which are well, and one is well following an amputation.

Of the 593 cases, 68 failed to recover. Some of these deaths were due to a continuation of the etiology which caused the disease in the first place, and were really the development of new cancers from the same causes reproducing the same effects. This is true especially in cases of lip cancer, where the etiology has been bad teeth and tobacco. If the patient continues with these causes after his disease has been healed, it will almost certainly recur. The fact that he has grown cancer is proof that his tissues and blood furnish a good place for the disease to grow. If the local irritation is continued, there can be no other result but that the disease will reproduce itself.

Various kinds of pernicious meddling before coming for treatment doubtless account for some failures by stimulating deep extension and metastasis. In this class, rented radium may be mentioned, also radium in the hands of inexperienced persons who generally know little or nothing about the physics and chemistry of the element they are using, the pathology of cancer or the anatomy or physiology of the tissues in which it grows.

The instruments used were tubes and needles. The tubes were 15, 30 and 50 mgm. each; needles contained from 5 to 12½ mgm. each. In computing our dose we take into consideration the actual diseased area and about ¼ in. beyond. The tubes are arranged to cover this area, screened with ½ mm. silver and 1 mm. rubber, and kept in place by adhesive. The depth is estimated and the tubes left in place long enough to deliver double an erythema dose at the deepest part we wish to reach. We give large enough doses to destroy the disease absolutely, disregarding burns. In cases where the operation of the law of the light decreasing inversely as the square of the distance would prolong our treatment to too great an extent, we use needles directly in the diseased area. When this is done, the dose in milligrams can be reduced to from ⅓ to ¼ the amount used when the radium is applied externally, since when the radium is buried, 100 per cent of the radiation is effectual.

A HISTORY CHART FOR RADIUM THERAPY*

BY CARROLL CHASE, M.D.

BROOKLYN, NEW YORK

THE history chart here illustrated is the result of considerable experience in attempting to keep accurate records of radium therapy over a period of some years. It is printed from an electro on both sides printing from the ordinary black typewriter ribbon. It is 11 × 8½ in. This size allows of vertical filing in the ordinary deep desk drawer. The charts are arranged alphabetically, though a further index of

FIG. 1.

of a heavy bond paper, known as ledger paper; this being chosen in preference to bristol board because it wears better, is more easily handled in the typewriter and takes up less room in filing. It is printed in red, as this makes a good contrast to the the cases may be made, if desired, according to the disease or condition.

Although the chart speaks largely for itself, a few explanatory remarks may aid in understanding it. In filling out the top, the patient's name is given in full, and

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

should she be married, her husband's name is also given. The items on the blank in regard to the telephone number and office hours of the physician referring the case will often save time when it is desired to report on the patient's progress or to get further information. The space

A—Operable
B—Borderline or doubtfully operable
C—Inoperable
D—Advanced and hopeless
E—Recurrences, local or regional

To this I have added one more group, F,

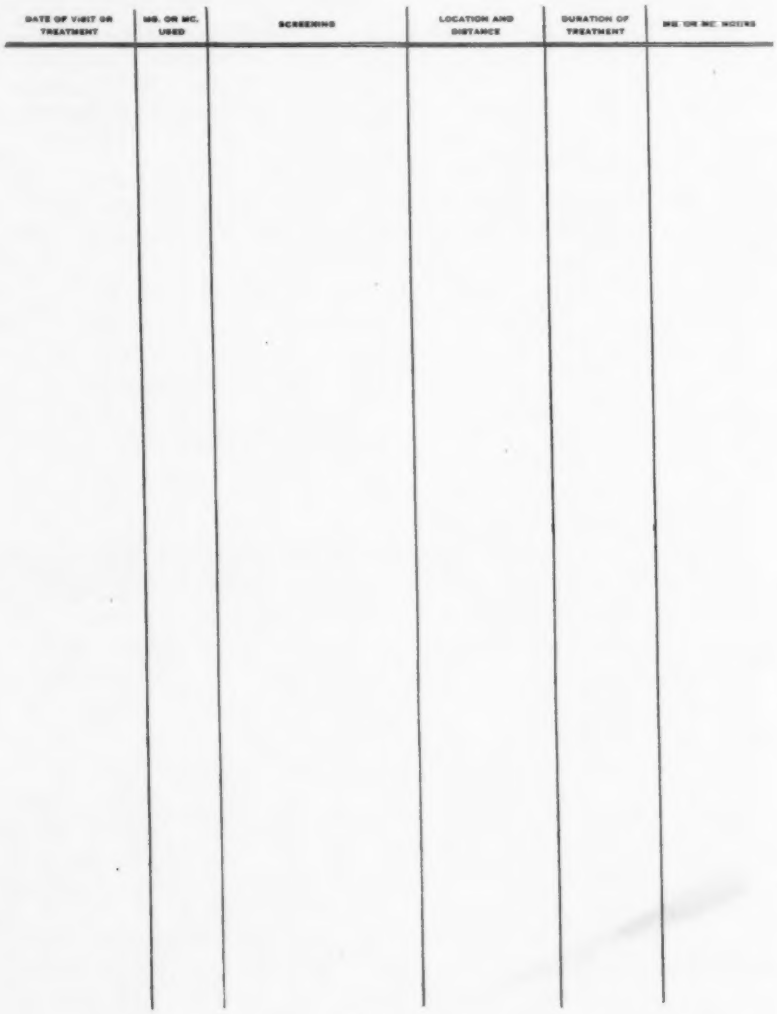

FIG. 2.

for "Previous History" and "Present Condition, local and general" is large enough so that if small type is used, considerable detail may be given.

The grouping of cases follows that in the schedule submitted by the Research Committee of the American Radium Society in 1920, and is as follows:

of such special odd cases as do not easily fall into one of the five groups. The "Charge," perhaps, had best be noted on the chart in some simple code. The last space on the front page, headed, "Final Summary and Remarks" ordinarily is not filled out until the case is discharged. This has proved quite valuable in checking

over cases for end results, and in studying technique.

The other side of the sheet is used as follows: If a treatment is given, the various columns are filled out as indicated and a line is drawn directly across the page under this. If more than one person is giving treatments, such entries should be initialed. If a visit without treatment is to be noted, it is typed in without any reference to the columns, and a similar line is drawn beneath it. Telephone reports of the patient's condition are also recorded here. By thus noting treatments and incidental visits in chronological order, the history is rather more easy to follow. Follow-up reports at definite intervals should be obtained from many cases and may be typed on the chart exactly as are treatments or incidental visits.

Should this side of the sheet not be of sufficient length to hold the entire history, a second chart may be attached to this, or a sheet of plain paper of the same size and with the same ruling may be used. These are best held together at the top by a paper fastener which cannot slip off. With the great majority of cases, it will save time and space to make a diagrammatic record of the extent and location of the lesion on printed anatomical sheets such as are sold by the American Medical Association.

It will be observed that this chart does

NAME	JONES, Mrs. Mary M. (Mrs. James T.)			DATE OF FIRST EXAMINATION: July 8, 1920.	CASE NO: 1491
ADDRESS	1234 Main Street, New York, New York.		REFERRED BY	NAME: Dr. John Smith,	
				ADDRESS: 5000 Centre Street, New York, New York.	
TELEPHONE	Bell 0012			TELEPHONE: Bell 0034	
AGE	69	w.s.w. Married		OFFICE HOURS: Daily 9:00 to 12:00 Mon., Wed., & Fri. 5:00 to 7:00	

PREVIOUS HISTORY: General health has been unusually good; no serious illness since childhood. Complexion has always been clear. Cannot remember ever having had any trouble with her skin until one year ago, when she noticed what she thought was a small wart on the left cheek about 2 cm. directly below the center of the left eyelid. This started without any apparent cause. It has gradually increased in size until the present time, but has never bled or caused any pain. Has had no treatment whatever for it.

Family history: negative, excepting that she believes her maternal grandfather, who died at about the age of 80, may have had cancer of the stomach.

PRESENT CONDITION — LOCAL: There is a warty growth roughly circular, about 1 cm. in diameter, located about 2 cm. directly below the center of the left eyelid. It has an estimated thickness of 4 mm. It seems to be entirely in the skin and is freely movable, not being attached to the structures below. The surface is rough and horny but not ulcerated. Excepting for this growth, the skin on the face is unusually clear for a woman of her age.

GENERAL: Health seems excellent - is active, has a good color. Systolic blood pressure of 150 and diastolic pressure of 95.

BLOOD FINDINGS: Not noted.

DIAGNOSIS: Evidently a simple epithelioma of the skin, strictly localized.

GROUP | MICROSCOPICAL FINDINGS: No section taken.

PROGNOSIS & RECOMMENDATIONS: Prognosis good. Radium treatment recommended with the expectation of an easy cure

CHARGE: None- (Doctor's wife)

FINAL SUMMARY & REMARKS: Apparent cure. Had the first dose been 25% larger, the second treatment might not have been necessary.

FIG. 3.

not in any way conflict with the suggestions of the Research Committee of the Society, but that it allows of much more detail.

The writer understands that this chart is far from perfect, and therefore would much appreciate criticism of it, as it is his wish to make it as practical and comprehensive as possible.

DATE OF VISIT OR TREATMENT	MG. OR MC. USED	SCREENING	LOCATION AND DISTANCE	DURATION OF TREATMENT	MG OR MC HOURS
July 8, '20	50 mg.	1/2 mm. of aluminum	In contact with the skin	45 minutes	37 1/2 mg. hours
	Application covered an additional area about 5 mm. wide all around the growth.				
July 15, '20	Reaction beginning to show; skin close to the growth moderately red. Has had no pain.				
July 22, '20	Evidence of a decidedly sharp reaction. Entire area is tender but not painful. No constitutional symptoms.				
Aug. 4, '20	Reaction is fading and growth is decidedly smaller.				
Aug. 14, '20	Reaction is practically gone. The growth has apparently cleared up excepting for an area about 3 mm. in diameter at about the center of the original tumor, where the skin is still round and slightly elevated.				
Aug. 21, '20	50 mg.	1/2 mm. lead + 1/2 mm. of rubber	In contact with the skin	40 minutes	33 1/3 mg. hours
	Application was made to cover the remaining growth and an area perhaps 2 mm. wide around it; the surrounding skin being protected by 2 mm. of lead lined with rubber.				
Sept. 4, '20	Sharp reaction over the area treated. A fairly thick scab has formed.				
Sept. 27, '20	Reaction is gone and the scab has fallen off, leaving practically healthy skin over the area treated; though the skin is somewhat redder than normal.				
Oct. 20, '20	The condition is seemingly cured. It is difficult to determine exactly where the growth was. Patient asked to report any future change in her condition.				
May 1, '21	Patient called today by request, and shows no trace of the former lesion. Apparently cured.				

FIG. 4.

TWO IMPORTANT POINTS FROM THE RADIUM THERAPIST'S STANDPOINT REGARDING CANCER IMMUNITY*

BY CARROLL CHASE, M.D.

BROOKLYN, NEW YORK

AS a premise to the subject, it must be granted that every individual possesses a certain inherent resistance to cancer, no matter of what type. This ordinarily is referred to as "cancer immunity." Were it not for this natural resistance, cancer would be a very much more rapid and fatal malady than it now is. As a corollary it follows that the man treating cancer, be he physician, surgeon, or radium or *x*-ray therapist, should always bear this fact in mind, and do everything within his power to conserve this immunity.

The writer makes no pretense of having anything particularly new to present regarding this subject, but he does feel very strongly that the arguments which follow, and the conclusions to which they lead, have never been sufficiently emphasized or heeded, and that they really deserve thoughtful consideration.

What this immunity is, and where it resides, is today not known; but the time is undoubtedly coming when we will have much more knowledge regarding it. However, there is already considerable evidence that some substance, existing largely or entirely in the blood, accounts for the phenomenon of immunity. It seems to be definitely established that this immunity-giving substance (or substances) really exists, and that it is the loss or diminution of it, and not the production of a new poison in the later stages of cancer, which accounts for the train of symptoms indicating loss of immunity.

An example of the attention which is being given to the various blood findings in cancer, may be found in the studies of Dr. Georgine Luden of Rochester, Minnesota, on "Cholesterol," published in the *Journal of Laboratory and Clinical Medicine*, October, 1918, iv, No. 1. The conclusions are too lengthy to be quoted here.

There has been gathered a certain amount of evidence that the two procedures of blood-letting (especially repeated hemorrhage) and anesthesia with one of the solvent group of anesthetics (ether, chloroform or ethyl chloride) both tend to lower, if not to destroy entirely, an individual's immunity against cancer. There is accurate proof of this as to mouse tumors of various kinds; but for obvious reasons, similar experimental work cannot be done on man.

Attention is drawn particularly to an article by Gaylord and Simpson, of the New York State Institute for the Study of Malignant Disease, at Buffalo, entitled, "The Effect of Certain Anesthetics and Loss of Blood upon the Growth of Transplanted Mouse Cancer," which appeared among the proceedings of the Ninth Annual Meeting (May, 1916) of the American Association for Cancer Research, and which was printed in the *Journal of Cancer Research* for July, 1916, 1, p. 379. The discussion of this paper is also given. Experiments here reported show that either a repeated moderate loss of blood or anesthesia with chloroform or ether (the effect of the former being the worse) very definitely affected the animal, so that inoculation with cancer substance from another mouse was almost invariably followed by tumor formation; while the control mice, neither bled nor anesthetized, showed sufficient resistance in about one-half the cases so that similar inoculation was entirely unsuccessful. A personal communication from Doctor Gaylord, in October, 1920, says: "The experimental evidence of immunity indicates the same phenomena, both in carcinoma and sarcoma."

Is it not true in looking back over one's experience for a period of years in the surgical treatment of cancer, that many

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

cases can be recalled where the patient went downhill rapidly after an operation, which, although perhaps not serious in itself, entailed a general anesthetic, and a greater or less loss of blood? Is it not equally true that as soon as a cancer patient begins to bleed to any extent, the general condition often becomes worse with a rapidity seemingly out of proportion to the amount of blood lost? That is to say, very much less harm would be done by a similar loss of blood in a non-malignant disease of comparable severity. If these observations are correct—and in the writer's experience, they seem to be—would it not be wise to make it a rule to use gas-oxygen when a general anesthetic is really necessary, or to use local or spinal anesthesia, as is most indicated? Thinking along similar lines, should not every necessary operation for malignant disease be made as nearly bloodless as possible? In another personal communication, Dr. Gaylord states further: "Since our original observation, no case in our hospital has been operated upon except by the use of gas or local anesthesia, and I have strongly advocated the absolute avoidance of the solvent group of anesthetics." Suppose, for a moment, we say that there is probably no truth in the theories here advanced regarding cancer immunity, but that we admit the bare possibility of their being true; would it not still be the part of wisdom to use the safeguards that have been indicated; especially as they make the surgeon's work no more difficult or dangerous, while they may do much for the patient?

To continue: if our line of reasoning thus far has been logical, it is an excellent argument for the use of radiation therapy, be it radium or *x*-ray, in every case in which it offers as good or nearly as good a chance of cure or palliation as would operation; because, ordinarily, radiation therapy does not require any general anesthetic, and further, because it is almost always bloodless.

SUMMARY

There is some evidence, which, though admittedly not conclusive, is certainly suggestive, that the use of any of the solvent group of anesthetics (chloroform, ether or ethyl chloride) or that the loss of blood in any considerable quantity tends to lower or destroy an individual's resistance or "immunity" against cancer.

Even the bare chance that this is true makes it seem wise to avoid entirely the use of the solvent group of anesthetics in malignant disease, and to make any necessary surgical procedure as nearly bloodless as possible.

Radiation therapy, using either radium or the *x*-ray, as is indicated, because such treatment ordinarily requires no general anesthetic and is bloodless, should be the method of choice in all cases where surgery does not offer a distinctly better chance of cure or palliation.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

MIDWINTER MEETING CENTRAL SECTION AMERICAN ROENTGEN RAY SOCIETY

SEELBACH HOTEL, LOUISVILLE, KY., FEBRUARY 24, 1923

THE FOURTH ANNUAL MEETING OF THE EASTERN SECTION OF THE AMERICAN ROENTGEN RAY SOCIETY

The Fourth Annual Meeting of the Eastern Section of the American Roentgen Ray Society was held at the Ritz-Carlton Hotel, Atlantic City, N. J., January 25, 26, 27, 1923, under the presidency of Dr. Charles A. Waters of Baltimore. There was an attendance of approximately three hundred and fifty members and guests.

A very complete and interesting program was provided by the President. Notable among other features were: *Localization of Brain Tumors by Cerebral Pneumography*, by Dr. Walter Dandy of Baltimore, and an illustrated address, *A Diagnosis of Brain Tumors Based upon the Clinical History, Examination, X-Ray, and the Pathology as Exposed by Operation*, by Dr. Joseph C. Bloodgood of Baltimore.

Considerable time was devoted to a discussion of deep therapy, with consideration of dosage estimation and the most suitable technique, especially in cases of malignancy. In these discussions Dr. J. T. Geraghty of Baltimore and Dr. F. C. Wood and Dr. James Ewing of New York participated.

At the executive meeting which followed the scientific sessions, the following officers were elected for the ensuing year:

President: Dr. Thomas A. Groover, Washington, D. C.

Vice-President: Dr. Charles Eastmond, Brooklyn, N. Y.

Secretary: Dr. William C. Wescott, Atlantic City, N. J.

The manufacturers exhibited a very comprehensive line of their new developments.

Charles Eastmond, M.D.,
Secretary.

CORRESPONDENCE

To The Editor:

At the last meeting of the American Radium Society, the late Dr. Russell H. Boggs and I made a real effort to get recognition of radium as an office expense, or to obtain some depreciation value. We foresaw the possibility of our radium decreasing tremendously in value. As a matter of fact, it has decreased in value fifty dollars a milligram, which receives no recognition from the government unless the loss is established by sale. We employed Mr. Charles M. Johnston to present this matter at Washington, together with a petition signed by the radium owners; and I am enclosing herewith his final report,* which I think should be published in the JOURNAL, so that all the members may know what has been done.

Yours very sincerely,
George E. Pfahler,
Ex-President, American Radium Society.

Jan. 20, 1923.

*In addition Mr. Johnson's letter will be found at the end of the editorial section.

DECISION OF INTERNAL REVENUE COMMISSIONER ON APPLICATION FOR CHANGE IN RULING ON RADIUM

Reference is made to your recent request on behalf of the American Radium Society and of other owners of radium in the United States for a reconsideration of O. D. 837 in which it was held that the cost of radium used as a therapeutic must be treated as a capital expenditure and that radium is not subject to depreciation.

You state that owing to the great cost of radium, the experimental character of its use, and difficulty in selling it and the possibility of the discovery of some method of treating cancer which will decrease the market value of radium you consider that a depreciation allowance of fifteen per cent should be granted or that physicians using it should be permitted to treat the cost as a business expense in the same manner as the cost of drugs.

The motives of policy which you have suggested such as the desirability of encouraging the use of radium and preventing the commercialization of its use may not be taken into consideration by this Bureau in administering the Federal Income tax laws, however excellent these motives may be. The test of the allowance of this deduction is the same as the test of the allowance of every other deduction and depends upon whether it meets the requirement of the statute. The Bureau is without authority to set aside the express provisions of the Revenue Act of 1921 or any other revenue act even if the administration of these provisions imposes a hardship upon the taxpayer or group of taxpayers.

The provisions of the Revenue Act of 1921 relating to depreciation are set forth in Section 214(a) (8) which provides for the allowance of:

"A reasonable allowance for the exhaustion, wear and tear of property used in the trade or business, including a reasonable allowance for obsolescence. In the case of such property acquired before March 1, 1913, this deduction shall be computed upon the basis of its fair market price or value as of March 1, 1913."

Under this section the allowance of depreciation is limited to such property as is subject to "exhaustion, wear and tear," that is, to property that has a life extending beyond a year but is not of such indefinite life that the depreciation which it sustains is negligible. The measure of depreciation is based on the probable life of the property as determined from its character and use.

An arbitrary deduction of fifteen per cent for depreciation, therefore, is not allowable as the depreciation of radium cannot possibly be based on a probable life of six and two-thirds years. On the contrary, as it was set forth in O. D. 837, the life of radium is so indefinite that depreciation is negligible.

It is also not possible to allow the deduction of the cost as an item of expense. Inasmuch as radium is not a material consumed or worn out through use during the taxable year, it represents a capital expenditure which under Section 215(a) of the Act is not deductible.

With reference to your statement that the discovery of a new method of treating cancer may result in rendering the use of radium obsolete, you are advised that in the event of its becoming obsolete a deduction for the loss of useful value may be claimed in the return for the year in which its use is abandoned. If the radium is sold at a loss either by a taxpayer or his estate, the loss may be claimed as a deduction from any income received whether from professional services or other sources. For this reason it is not believed that any undue hardship is imposed upon physicians using radium for treatment by the application of these principles.

In view of the express provisions of the statute it is not considered that O. D. 837 should be modified or reversed.

Respectfully,
C. P. Smith,
Acting Commissioner.

PRESENT RULING

Since the full life of radium has been scientifically estimated at such an extended period and since no appreciable depreciation results from its continued use as a therapeutic agent, the depreciation occurring during the lifetime of any individual owner is practically negligible. It is held,

therefore, that radium which is used as a therapeutic is not subject to depreciation for income tax purposes and its cost must be treated as capital expenditure. The return of capital will be realized upon its sale or other disposition.

Cum. Bul. No. 4, June, 1921.
Treasury Dept. Page 178,
Office Dec. 837.
Ruling 10–21–1496.

CENTRAL SECTION

FOURTH ANNUAL MEETING

PRELIMINARY PROGRAM

The Fourth Annual Meeting of the Central Section of The American Roentgen Ray Society will be held in the Seelbach Hotel, Louisville, Ky., on Saturday, February 24, 1923.

The program as arranged for the meeting is presented herewith. Those who can attend are promised an unusually fine opportunity for discussion. Visitors are welcome to all scientific sessions.

SATURDAY MORNING, 9 O'CLOCK

Dr. Bernard H. Nichols, Cleveland, Ohio.
Urography.

Laboratory equipment. Importance of urography as compared with gastro-enterography. Necessity of careful history and laboratory study to determine the method of procedure. Roentgenologist a consultant and not a technician. Technique. Demonstration of results with lantern-slide illustrations.

Discussion

Dr. W. O. Upson, Battle Creek, Mich.
Study of the Esophagus.

First, Dr. Case's method of examining the esophagus; second, the importance of examining the esophagus in all cases of the barium meal examination; third, the appearance of the normal esophagus; fourth, illustrative cases of the more common lesions, such as cardiac spasm, chronic esophageal obstruction, congenital esophageal obstruction, diverticula, carcinoma of the esophagus, etc.

Dr. John D. Osmond, Cleveland, Ohio.
Obstruction of the Esophagus.

When available in diseases of the esophagus, the direct inspection through the esophagoscope should be made in addition to the fluoroscopic examination and the *x*-ray films. However, the preliminary examination of choice is the *x*-ray. In complete or partial obstruction, at least twenty-five possible causes must be considered. Routine examination of the esophagus should be made in most cases where examination of the stomach is requested.

Discussion

Dr. A. W. Crane, Kalamazoo, Mich.
The Chronic Appendix in Roentgenological Work.

Dr. Alexander B. Moore, Rochester, Minn.
Benign Tumors of the Stomach with the Roentgen Findings in Seven Cases.

Discussion

Dr. W. H. Stewart, New York City.
An Unusual Case of Lymphosarcoma of the Thymus with Metastasis.

Dr. B. R. Kirklin, Muncie, Ind.
Osteochondritis Deformans Juvenalis.

Discussion

Dr. Kennon Dunham, Cincinnati, Ohio.
Acute Pulmonary Tuberculosis.

Discussion

SATURDAY AFTERNOON, 2.30 O'CLOCK

Dr. J. M. Martin, Dallas, Texas.
Fifteen Years' Experience with the Fractional Dose Method of Treating Cutaneous Malignancies. (Lantern Slide Illustrations.)

A general review of the roentgen technique used in the treatment of 2,000 cases of cutaneous malignancies. A comparative study of the fractional and massive dose methods as applied to the treatment of malignant lesions of the cutaneous structures. A description of a practical follow-up system covering a period of five years.

Discussion

Dr. A. W. Desjardins, Rochester, Minn.
Protection against Radiation.

General discussion of dangers from radiation to patient and to radiologist,

under different working conditions, and methods of protection. Preliminary report of experiments to determine thickness of lead required for protection in therapy laboratories particularly, with results.

Discussion

Drs. Arthur W. Erskine and Scott M. Smith, Cedar Rapids, Iowa.

A Comparative Study of Various Filter Materials.

Reasons for using filters, and desirable qualities in filter material. Description of methods employed in obtaining data. The economical limit of increase in filter thickness and description of a simple method of determining it. Comparison of results obtained using various materials as filters. Possible relation of atomic numbers of elements to efficiency as filters. Conclusions.

Dr. James N. McCoy, Vincennes, Ind.

Physiological Dose of Roentgen Rays.

Reasonable to assume certain doses of *x*-rays adapted to certain purposes. Superficial cancer, object of earliest *x*-ray treatment. Basis for dosage in deeper-seated disease. Destruction of lesion. The object of treatment. Typical desired superficial reaction. Advisable that superficial lesion receive only such rays as are expended in it. Hard rays passed the skin without effect on it. Valueless against skin malignancy. Lethal dose to be avoided in treating hypertrophies. The discovery of Lodge. The governing principle of *x*-ray therapy. Radical versus conservative. Discussion of high voltage treatment. Requisites of curative dose for malignancy. Sufficient intensity to reach the pathology and the required volume of rays to accomplish physiologic change.

Dr. Otto Glasser (by invitation), Baltimore, Md.

Roentgen-Ray Dose.

The measuring instruments which in the practical use of *x*-rays are most employed for the determination of the "practical dose" are the milliammeter and the kilovoltmeter, the latter checked up with the sphere-gap. The most recent measuring instruments based on ionization allow us to determine accurately the quality and the quantity of radiation for every point of the exposed body. This can be done with the Freidrich iontoquantimeter method of determining the "effective wave-length" and measuring the intensity with the Duane ionization chamber and with the method of Dessauer using the Bachem electroscope. To these methods of determining the "practical dose" must be added the important researches on the problem of "absolute dose."

Discussion

Dr. Henry Schmitz, Chicago, Ill.

The Changes in Cervical Carcinomatous Tissue exposed to Radiations.

Discussion

Dr. Charles Goosman, Cincinnati, Ohio.

Results with Modern Radiotherapy in Bladder Tumors.

These cases have not been responding satisfactorily to surgery. The genitourinary specialist will usually be glad to call in the aid of radiotherapy. Results with combined radium and deep roentgen treatment are better than with any previous method. Correct technique important. Preliminary cystotomy a disadvantage.

Dr. William A. Evans, Detroit, Mich.

Result of Deep Roentgen Treatment of Gastrointestinal Lesions.

BUSINESS MEETING

Immediately after the close of the Scientific Session

Election of Officers

SATURDAY EVENING, 7 O'CLOCK

BANQUET

SYMPOSIUM ON THE SACROILIAC AND LOWER LUMBAR SPINAL VERTEBRAE

Dr. Paul Magnuson (by invitation), Chicago, Ill

What May We Call Radiographic Evidence in Low Back Pain?

Dr. Hollis E. Potter, Chicago, Ill.

Radiographic Evidence.

Discussion of this Symposium to be opened by:

Dr. P. M. Hickey, Detroit, Mich.
Dr. Edward S. Blaine, Chicago, Ill.

Lantern Slides.

Notify Dr. D. Y. Keith, Suite 746 Francis Bldg., Louisville, Ky., number of slides you wish to present.

COMMERCIAL EXHIBITS

SUNDAY PROGRAM

Golf
Sight Seeing

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page i of this number of the JOURNAL. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

Dear Dr. Pfahler:

Pursuant to the instructions of yourself and Dr. Russell H. Boggs, of this city, I at once began the preparation of a petition to be filed with the Internal Revenue Office at Washington, requesting a modification of the present ruling on radium.

The untimely death of Dr. Boggs was a real misfortune in this matter, as he was very familiar with many facts that would certainly have had weight with the Department at Washington. However, after considerable labor and investigation, I prepared a petition asking that the present ruling be modified either by permitting the cost of radium to be charged as a current expense, with a provision to the effect that in the event of the subsequent sale of the radium the selling price would be charged as income, or that a depreciation allowance be allowed each year on all radium held by physicians and used for therapeutic purposes.

The petition was very lengthy, covering about ten typewritten pages, and later, a five-page supplement, amplifying some of the arguments in the original petition, was added. Both the original and the supplement were presented by me to Commissioner Blair, of the Internal Revenue Department, and one of his assistants, Mr. Mattox, at Washington, at a conference on this matter that lasted upwards of two hours. I had attached to the petition the copy of the resolution passed at the meeting of the society in St. Louis, and also the original petition signed by the physicians individually at the same meeting. I went carefully over all the matters set forth in our petition, resolution and the physicians' petition, with the above-named gentlemen, and was shown every consideration and courtesy by them. Unfortunately however, they were unable to grant us relief.

The decision, a copy of which is hereto attached, explains the position of the Commissioner in detail.

For your information and for the information of any physicians not familiar with the present ruling, I am also attaching hereto a copy of the present ruling, O. D. 837, cited in the Commissioner's decision.

Yours very truly,
Charles M. Johnston.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

WHITCHER, B. R. Blood Changes in Myelogenous Leukemia Following Radium Treatment. *Boston M. & S. J.*, Sept. 7, 1922, clxxxvii, No. 10, 349.

The author's observations led him to believe that the application of radium in myelogenous leukemia does produce an apparently beneficial effect on the patient, if the amount of radium applied is regulated with caution; as the leucocyte count is reduced to nearly its normal level, the myelocytes are greatly decreased, and at times made to disappear altogether, the blood is brought to a more nearly normal appearance, and apparent general improvement takes place in the patient's clinical condition. But the treatment should be given at regular intervals. However, radium is a factor fraught with danger, and caution is necessary in regulating the amount to be applied, lest an excessive dose or too frequent application may cause undue destruction of the leucocytes, and so injure the reproductive powers of the bone-marrow that a rapid leucopenia and anemia result.

As the outcome of the experience of the author and his colleagues at the New York Post-Graduate, the present procedure is to apply the radium over the enlarged spleen only, and over the lymph-nodes, if enlarged; but to let the bone-marrow alone until the myelocytes have entirely disappeared from the blood. There appears to be a danger that, in treating the bone-marrow at the same time, its power to produce new red cells may be weakened so that the red cells and hemoglobin decrease along with the leucocytes.

KIRKENDALL, BEN R. Pre-Operative and Post-Operative Radium Therapy: Report of Cases, Dosage and Methods. *Obio M. J.*, Dec. 1, 1921, xvii, No. 12, 837.

The author believes that cases of carcinoma of the vagina and prostate are best treated with radium alone. Cases of cancer of the cervix and uterus, which have responded well to the treatment should rarely be hysterectomized later, as distant quiescent diseased cells may be stimulated to recurrence. Radium can be used to advantage before surgery to make non-surgical cases surgical. Radium after surgery may make a success of the operation. Its use in recurrences is palliative, but it may cure.

BROGDEN, JAMES CHESTER. Actinomycosis of the Gastrointestinal Tract. *J. Lab. & Clin. M.*, Dec., 1922, viii, No. 3, 180.

The author reports 14 cases studied in the Mayo Clinic, 13 of the 14 cases having been discovered within the last four years. No report could be obtained of 3. One has been treated only four weeks. Of the remaining 10, 6 are dead with an average length of life after onset of the disease of three years. One patient was operated upon and had no symptoms of recurrence four years afterward. One was apparently cured after four years of medical treatment, and 2 are markedly improved after taking iodides and roentgen-ray and radium treatment. The author concludes that a chronic discharging sinus in the lower abdomen, especially after operation and drainage of an appendiceal abscess, should arouse suspicion of actinomycosis, and repeated examinations for the ray-fungi should be made. Early operation and excision of the diseased area before the infection spreads to the surrounding tissues, frequent roentgen-ray and radium treatments over the abdomen, and large doses of potassium iodid by mouth and sodium iodid intravenously offer the best hope of cure. In the later stages, after extension of the disease to the adjacent organs and sinus formation, radical surgical measures are of no avail. Some patients apparently are cured under treatment with radium, roentgen ray, and the iodides; others improve wonderfully only to have recurrence in from two to four years. Death usually occurs from cachexia and extension of the disease to the liver and thorax.

MACCARTY, WILLIAM CARPENTER. Does Cancer Arise in Chronic Gastric Ulcer? *J. Am. M. Assn.*, Dec. 2, 1922, lxxix, No. 23, 1928.

From an experience of more than 1,400 gastric specimens, MacCarty concluded that cancer is so often associated with chronic gastric ulcer that such a gastric ulcer should always be considered as possibly malignant. He knows of no clinical or laboratory method by which the differential clinical diagnosis can be made. From actual experience, he knows that most chronic gastric ulcers with a diameter greater than 2.5 cm. are cancers. He does not know how to tell whether the ulcer or cancer was primary. Ulcers of the stomach may be divided, for practical purposes, into 5 groups; the simple acute peptic ulcer; the chronic ulcers which are tuberculous or syphilitic; the chronic ulcer, the exact etiological factors for which are unknown; the chronic ulcer in which there is a neoplastic process in the borders of the mucosa; the gastric ulcer which shows carcinoma, not only in the borders, but also in the base. There are no positive clinical signs, symptoms or laboratory tests by which these 5 groups of ulcers can always be differentiated. Advanced carcinomas may be seen with the roentgen ray, and if the roentgenologist discovers an ulcer which he estimates to be larger than 2.5 cm. in diameter, the guess of cancer will be correct in a very high percentage of cases. It is, however, only a guess for practical purposes, but has some value.